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HABITAT USE BY MOUNTAIN GOATS IN SOUTHEASTERN ALASKA

By
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Volume V

Progress Report
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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: Kenneth Raedeke and Joseph Fox, University of Washington; and Glen Contreras, U.S. Forest Service

Project No.: W-22-1 Project Title: Big Game Investigations

Job No.: 12.4R Job Title: Habitat Use by Mountain Goats in Southeastern Alaska

Period Covered: July 1, 1981 through June 30, 1982

SUMMARY

During the past year of study, the 7 surviving mountain goats (*Oreamnos americanus*) from the original sample of 10 on the Lower Cleveland Peninsula (LCP) study area were monitored to assess movements and habitat use. Two additional goats, 1 of each sex, were collared in summer 1981. A total of 299 relocations were made of the collared goats on the LCP as of 30 June 1982.

To assess habitat use patterns by goats in more typical habitat, work was initiated this year on the Upper Cleveland Peninsula (UCP). Nine male and 8 female goats were radio-collared on the UCP in July 1981 and have since been monitored continuously. A total of 379 relocations of these goats was made as of 30 June 1982.

Availability of habitat types within the study area was determined from a random sample of 1,527 points located on the UCP. Habitat selection by goats was evaluated by 2 methods.

Goats on the LCP and UCP are highly selective in their use of available topographic and vegetational features. Steep, broken terrain within 500 m of cliffs is commonly used in all seasons, but distinct trends are evident in use of elevation, slope, aspect, canopy cover, and timber volume throughout the year. Although some differences in habitat use occur between the LCP and UCP areas, forest habitat is used extensively during winter by all goats studied.

Data from this study have been used to prepare 2 publications, "Mountain Goat Ecology on Cleveland Peninsula, Alaska 1980-82" (Appendix A) and "Group Size and Movements of a Dispersed, Low-density Goat Population with Comments on Inbreeding and Human Impacts" (Appendix B).

Key words: habitat use, mountain goat, *Oreamnos americanus*, Southeastern Alaska.

CONTENTS

BACKGROUND

Research during the past 5 years has begun to reveal the importance of forest habitat to mountain goats <u>Oreamnos americanus</u> in the coastal region of Washington, British Columbia, and Alaska (Hebert and Turnbull 1977; Schoen 1978, 1979; Fox 1979<u>a</u>, <u>b</u>; Stevens and Taber 1980; Schoen and Kirchhoff 1982; Smith 1982). During winter, heavy snowfall accumulations force goats to lower elevations and into the shelter of forest cover. As more of these forest areas are entered for logging, mining, or other developments, the potential for serious impact to critical goat habitat increases. A detailed understanding of goat-habitat relationships will be necessary to predict areas of conflict and minimize human impact.

This project was begun as a cooperative study in 1980 (Harrington 1980) and has been continued and expanded during the following years. It is the 1st intensive radio-telemetry study of goat habitat use in southern Southeast Alaska and is intended to fill the information gap needed to identify and protect forested winter habitat.

OBJECTIVES

To monitor goat movements and determine seasonal habitat use in Southeastern Alaska and to evaluate physical and biological parameters of seasonal goat habitat.

PROCEDURES

During the report period, the Upper Cleveland Peninsula (UCP) was selected as an additional study area. The UCP is more representative of goat habitat in southern Southeast Alaska than the Lower Cleveland Peninsula (LCP). Fig. 1 shows the relative sizes and locations of the study areas. Most capture effort was directed at the UCP, but additional goats were also collared on the LCP.

Capture and telemetry techniques followed the procedure of Nichols (in press). Standard measurements and age estimates were taken and blood samples collected whenever possible. Percent hemoglobin and packed cell volume were determined by the Ketchikan General Hospital Laboratory using uncoagulated specimens; standard serum parameters were measured by Pathologists Central Laboratory, Seattle, Washington. Serum samples were also frozen and stored for eventual testing for specific disease antibodies by an appropriate lab.

Environmental and habitat data gathered visually on telemetry flights were recorded for each relocation (Smith 1982). Locations were coded using an x-y coordinate grid overlay with 2.6 ha cells. To provide an alternative method of assessing habitat use and to enable future discriminant function analysis, topographic and forest type maps of the UCP were sampled for the same parameters reported for the LCP (Appendix A). For this sampling, 10% of the UCP grid cells were randomly selected from the overlay.

The lower left corner of each cell was used as a point sample and the following data were recorded: elevation, slope, aspect, distance to nearest cliff (defined as an identifiable area of >50° slope), distance to alpine meadow, vegetation type, and timber volume (see Appendix A for further discussion of procedures). All data collected were entered onto "floppy discs" using a Vector-Graphics VIP-3 microcomputer. Programs for frequency analysis and limited statistical evaluation (chi-squared tests) were written by the author and used to generate results for this report. Future reports will contain more detailed analyses as biometrician assistance and enhanced computer capabilities are made available.

RESULTS

Capture and Telemetry

A total of 20 goats (10 males, 10 females) was captured between 9 July and 13 September 1981. Nineteen of these goats, ranging in age from 1.1 to 10+ years, were fitted with radio-collars; the other, a 3-month-old kid accidentally struck by a dart fired at its mother, was ear-tagged. In addition, 2 male goats died during capture attempts, 1 as a result of a fall and the other due to suffocation when it slumped down with its head under its chest and could not be quickly reached and repositioned. Table 1 summarizes the results of the capture efforts and gives the status of all goats as of 30 June 1982. Body measurements, reproductive status of females, age structure of the captured sample, and results of blood analyses are on file in the Ketchikan office. It is anticipated that these data will be analyzed in conjunction with those collected by Lyman Nichols under Job 12.5R for a coauthored publication on reproductive biology and blood physiology of Alaskan mountain goats.

Table 2 presents the results of radio telemetry flights through 30 June 1981. Since the initiation of this project, 299 relocations have been made for goats on the LCP; 379 have been made on the UCP study area. Of these, 855 were sufficiently accurate to identify habitat type occupied at the time of relocation; 96% could be positively assigned to a 2.6 ha cell in the study grid system. This data base is large enough to allow breakdowns by study area, season and/or sex for some analyses, thus making it possible to identify trends in habitat use. Throughout the remainder of this report, the following seasonal periods are considered: Late Winter (1 January-31 March), Spring (1 April-15 June), Summer (16 June-31 August), Fall (1 September-31 October), and Early Winter (1 November-31 December). Continued monitoring of radioed goats will expand the data base, thereby increasing statistical reliability of results.

Habitat Selection

Visually Estimated Parameters:

Elevation. Table 3 and Fig. 2 demonstrate the seasonal trends in elevation use by goats in this study. Fig. 2a illustrates the pattern for male and female goats on the LCP, Fig. 2b gives trends for each sex on the UCP, and Fig. 2c compares trends for the combined sexes on both study areas. On the LCP, mean elevation at relocations increased steadily for both sexes from Late Winter 1980-81 through Fall 1981 then declined sharply in Early Winter 1981-82. In Late Winter and Spring, females moved slightly higher while males moved down slope. Goats on the UCP showed the same distinct elevational shift from high Summer and Fall locations to low elevation Early Winter sites. During Late Winter, both sexes used slightly higher mean elevations, then moved back down slope in Spring 1982. It is noteworthy that the only time both sexes on each study area were found to have the same mean elevation at relocations was during Early Winter, the time when breeding occurs.

Fig. 3 is a frequency histogram illustrating the difference in use of elevational zones by LCP goats in the mild Late Winter 1980-81 and the more typical Late Winter 1981-82 (see Appendix A, p. 11 for discussion of snow depth and winter conditions). Data for males are limited, so a high degree of confidence cannot be placed on interpretation of results. Nevertheless, this graph reveals that total use of areas above 460 m was less in the more severe winter (63% in 1980-81 as opposed to 53% in 1981-82). For females, use of areas above 600 m decreased markedly in 1981-82; the 300-460 m zone was used 3 times as much in 1981-82 as in 1980-81.

Slope. Table 3 and Fig. 4 present results of analysis of mean slope at relocations in both areas. Throughout the year, on the LCP, females consistently used areas with a greater mean slope than males (Fig. 4a). The divergence was greatest during Late Winter 1980-81 and Summer and Fall 1981 due to the males' more frequent use of ridgetops. Mean slope values for the sexes converged for LCP goats during Late Winter 1981-82 and Spring 1982. On the UCP, use of slopes by the 2 sexes of goats was more consistent, although males used steeper areas in Summer 1981 and slightly gentler slopes in Spring 1982 (Fig. 4b). On both study areas, for both sexes, mean slope increased between Fall 1981 and Early Winter 1981-82, declined in Late Winter 1981-82, and increased again in Spring 1982 (Fig. 4c).

Fig. 5 presents frequency distribution for use of slope categories by goats on the LCP for the Late Winter periods in 1980-81 and 1981-82. The most significant change in use of slope categories associated with different snow conditions was the reduced use of extremely steep slopes (66°) by both sexes, and a concentration of use in the 51-65° slope category.

Aspect. Table 3 and Fig. 6 present results of analysis of mean aspect at relocation, using a north-to-south continuum where North = 1, Northeast and Northwest = 2, East and West = 3, Southeast and Southwest = 4, and South = 5. Fig. 6a shows a slight decrease in mean aspect for both sexes on the LCP between Late Winter 1980-81 and Spring 1981 followed by a more or less constant increase in mean aspect used from Spring 1981 through Spring 1982. The result of this trend is that mean aspect was higher (i.e., more southerly) in the more severe winter of 1981-82. While males on the UCP show a similar gradual increase in mean aspect from Summer 1981 through Late Winter 1981-82 (Fig. 6b), UCP females were found to be highly variable in aspect selection. As might be expected, however, their highest mean aspect (southerly exposures) occurred during Late Winter 1981-82.

Fig. 7 clearly demonstrates the shift toward southerly aspects in Late Winter 1981-82 compared to Late Winter 1980-81 for both sexes on the LCP. In addition to decreased use of north-facing slopes in the more severe winter, females were less frequently found using ridgetop locations in 1981-82. Conversely, males were found to use ridgetops more often in 1981-82. This use of ridgetops occurred during periods of clear, cold weather when the snow was crusted and travel was relatively easy for goats.

Terrain. Table 3 lists frequency for use of broken terrain (i.e., ground surface areas characterized by numerous rock outcrops; cliff faces or boulders >2 m high; and/or gullys, scree, or fissures) by goats on both study areas. Goats on the UCP were found to use broken terrain almost exclusively, with the few relocations on smooth terrain generally occurring in Late Winter and Spring on slopes where uniform deep snow cover obliterated surface features. Use of broken terrain was slightly less on the LCP, possibly as a result of decreased availability of broken terrain on the more gentle, rolling ridges of the LCP. It is interesting to note, however, that on the LCP both males and females made greater use of broken terrain during the Late Winter of 1981-82 than in the previous, milder Late Winter 1980-81 (Fig. 8).

Canopy Cover. Table 3 and Fig. 9 present results of analysis of mean canopy cover at goat relocations on a seasonal basis. Females on the LCP remained in an area with a relatively uniform mean canopy cover of 50-60% with the exception of Summer 1981 when they used areas with less the 90% cover (Fig. 9a). LCP males, on the other hand, used areas with canopy cover >50% only during Late Winter 1980-81 and Early Winter 1981-82, and generally used areas of lower canopy cover than females. On the UCP, as with elevation and slope, males and females had more similar use patterns for canopy cover than goats on the LCP (Fig. 9b). Only in Spring 1982 did the 2 sexes use areas that deviated more than 5% in mean estimated canopy cover. In comparing overall trends between study areas (Fig. 9c), a similar pattern of use appears, but the magnitude of the changes with seasons differs. In both areas, mean canopy cover increased from Summer through Early Winter, declined slightly in Late Winter, then increased again in Spring to a level between the 2 winter values. Throughout the year, UCP mean canopy cover levels were lower than LCP values. This was particularly true in Summer and Fall when UCP goats were often found in alpine and subalpine habitat areas which are relatively scarce on the LCP.

Fig. 10 illustrates the change in frequency distribution of canopy cover values for LCP goats in Late Winter 1980-81 and Late Winter 1981-82. Females exhibit the expected trend of reduced use of lower canopy cover classes under heavy snow conditions, but males show the opposite trend. It is not known whether this is an anomaly associated with small sample sizes, or too-large canopy cover classes, or a real disparity in response to snow accumulation.

Vegetation. Table 4 provides a breakdown of percent use of various vegetation types by season for each sex on both study areas. Fig. 11 graphs the trends in percent use of old-growth forest by the radio-collared goats. On the LCP, females were found to use old-growth forest at least 50% of the time regardless of season, and over 80% of time from Early Winter 1981-82 through Spring 1982 (Fig. 11a). LCP males used old-growth forest somewhat less often than females in Summer 1981 and Spring 1982, females in Summer 1981 and Spring 1982, but otherwise showed substantial use of this vegetation type. On the UCP, females were rarely found in old-growth forest in Summer 1981, although males used this type 25% of the time (Fig. 11b). Use of old-growth forest by both sexes increased in Fall 1981 and reached a peak in Early Winter 1981-82 when it was used almost exclusively. Both sexes made less use of old-growth forest in Late Winter 1981-82, but still over 70% of all relocations occurred in this type. Comparing overall use of old-growth forest on the LCP and UCP reveals a similar pattern of rapid increase in use from Summer to Early Winter on both study area (Fig. 11c). The trends diverged in Late Winter 1981-82 when LCP goats continued to use old-growth forest over 90% of the time, whereas UCP goats used other types nearly 30% of the time.

Fig. 12 displays the patterns of use of all the vegetation types on a seasonal basis by both sexes of goats on each study area. On the LCP, the transition from Late Winter to Spring in both years was marked by increased use of the brush/slide, subalpine forest and alpine types (Fig. 12a). In addition, in Spring 1981, the LCP goats used the rock/cliff type 10% of the time. During Summer 1981, use of subalpine forest declined while use of brush/slide and alpine areas continued to increase. Fifty percent of relocations occurred in these open vegetation types. Use of alpine areas continued into Fall 1981, use of subalpine forest increased slightly, but the brush/slide type was not used during this season. The predominant use of old-growth in winter discussed above resulted in relatively little use of other types during this period. Fig. 12a also shows that during the more severe Late Winter of 1981-82, LCP goats used old-growth forest more often and brush/slide and subalpine forest types less often than in the milder Late Winter 1980-81.

On the UCP, the alpine vegetation type was the most heavily used in Summer 1981 (Fig. 12b). In Fall 1981, alpine use declined to approximately 30% as old-growth forest and rock/cliff types were increasingly selected. In Early Winter 1981-82, the old-growth forest was so heavily used that the only other vegetation type with a few relocations was the brush/slide type. In Late Winter 1981-82 as the snowpack accumulated and settled making travel easier for goats, use of the subalpine forest and alpine areas resumed, and the brush/slide type was avoided. Later in Spring 1982, goats again began to use the brush/slide type.

Map Assessed Parameters:

From the preceding assessment of visually estimated parameters, it is obvious that goats have specific patterns of habitat use. However, such information has limited application unless "use" can be compared with "availability" to determine the degree or statistical significance of selection of specific habitat parameters. Unfortunately, availability of all the parameters estimated visually at relocations cannot be practically determined for the overall study areas. Thus, it was necessary to employ the indirect approach of sampling topographic and timber type maps to generate a data base for statistical evaluation of habitat selection.

Appendix A (pp. 16-28) discusses the map sampling as well as chi-squared tests and discriminant function analysis of the map-based habitat and telemetry data for the LCP.

The UCP study area grid system was randomly sampled at an intensity of 10%, yielding 1,527 cells to generate frequency distributions for availability of an array of variables (Table 5). The 1,527 randomly chosen cells were separated into 2 groups, those found to be occupied at least once by a radio-collared goat during the past year and those not found to be occupied at all. This provided frequency distributions for the sampled variables for used and unused areas (Table 5). (It is recognized, however, that such cells might have been occupied by radio-collared goats during periods between relocations and/or by nonradioed goats at any time.) Finally to expand the sample of used locations, all other cells occupied by goats not included in the 1,527-cell sample were evaluated for the subject variables and were pooled with the randomly selected cells to generate another set of frequency values.

Table 6 lists results of chi-squared analyses of both samples of used vs. available cells, as well as used vs. unused and unused vs. available cells. From this, it can be seen that both samples of used cells differ significantly ($\underline{P} < 0.05$) from available ones on the basis of elevation, slope, aspect, distance to cliffs, vegetation, and timber volume in all cases except when comparing timber volume of all cells used with the 1,527 available cells. Chi-squared values for comparisons of the used vs. unused subsamples of the 1,527 cells also show significant ($\underline{P} < 0.05$) selection for each variable. None of the values for a comparison of the unused cells to the available sample is significant ($\underline{P} < 0.05$).

Because goats were found to be making selective use of elevation, and because some of the other variables may be correlated with elevation, it was thought that some of the significance indicated for variables in Table 6 might be an artifact of the goats' elevational distribution. To evaluate this potential, the expanded sample of "used" cells and the 1,527 "available" cells were subdivided into 500-ft elevational zones; new frequency distributions were determined, and chi-squared tests performed. The results in Table 7 show that in every case but 1, statistically significant ($P < 0.05$) selection is still evident for all elements tested. Thus, regardless of where a goat is located on an elevational gradient, it can be expected to be highly selective with respect to aspect, slope, distance to cliffs, vegetation type, and timber volume. Future reports will use discriminant function and canonical coefficient analysis to further investigate the direction, degree, and correlation of selection of these and other habitat parameters.

DISCUSSION

During the current reporting period, energy has been concentrated on data collection and relatively little analysis has been performed. Nevertheless, the treatment of data from the LCP presented in Appendix A reveals the potential strengths of discriminant function analysis and provides a thorough discussion of habitat selection by goats in this area. Future reports will provide similar evaluation of UCP data as well as in-depth comparisons of goat habitat use on the LCP and UCP study areas.

Although the broad applicability and ease of sampling associated with the analysis of map-based data make this technique highly attractive, there is also value in continuing to gather data on the visually estimated parameters. The primary advantage of the visual data is its finer resolution, and perhaps greater accuracy with respect to certain variables. In addition, some features such as terrain type, snow conditions, and estimated canopy cover can be determined visually at relocation sites, but not from maps.

As mentioned in Appendix A (p. 29), the greatest limitation of the map-based data is that its 2.6 ha cell scale may be too coarse to detect some real changes in habitat selection associated with variation between seasons and/or years. This problem, compounded by sample size limitations, is likely the cause of the failure to find statistically significant differences in selection for habitat variables based on grid cell sampling on the LCP between the mild winter of 1980-81 and the severe winter of 1981-82 (Appendix A, p. 18). It remains to be seen whether the visually estimated data can be analyzed in a manner which will reveal statistical significance of changes in selection between years. Biometric assistance and enhanced computer capabilities will facilitate this analysis in the coming report period.

The brief analysis of UCP data presented here reveals that goats are highly selective with respect to a broad array of habitat parameters. This is not too surprising inasmuch as few, if any, animals distribute themselves in a random fashion, and past studies on goats have indicated that this species is particularly selective for certain features such as proximity of "cliffy," escape terrain (Fox 1979b, Schoen and Kirchhoff 1982). As the data base is expanded in the coming year, it will be possible to perform more detailed analyses which will refine our understanding of the factors that influence goat distribution. Ultimately, it should be possible to use discriminant function analysis, as reported for the LCP in Appendix A, on the UCP data to develop a predictive model of goat habitat in southcoastal Alaska. Testing of the model through application of the UCP discriminant function to map data from another area to predict future locations of goats to be subsequently collared and monitored will provide a unique opportunity to take the study of wildlife-habitat relationships beyond the descriptive stage. In the end, it should be possible to assess the degree of confidence with which we can identify and protect important goat habitat in future timber sale or mining areas.

ACKNOWLEDGMENTS

J. L. Fox, K. J. Raedeke, and T. A. Hanley contributed substantially to this project this year through a cooperative agreement with the University of Washington and the USDA Forest Service Pacific Northwest Forest and Range Experiment Station. Glen Contreras of the Ketchikan area office of the Forest Service also arranged significant logistic and financial support. S. Brainerd performed the tedious job of sampling maps of the study area and, along with R. E. Wood, assisted in capturing and radio-collaring goats. J. McKernan ably handled the helicopter during capture activities; R. D. Hamlin continued to perform with skill and zeal on fixed-wing telemetry flights. Finally, J. Schoen, S. Miller, and D. E. McKnight contributed valuable time and ideas in discussing the direction and objectives of this project. To all these individuals, I am sincerely greatful.

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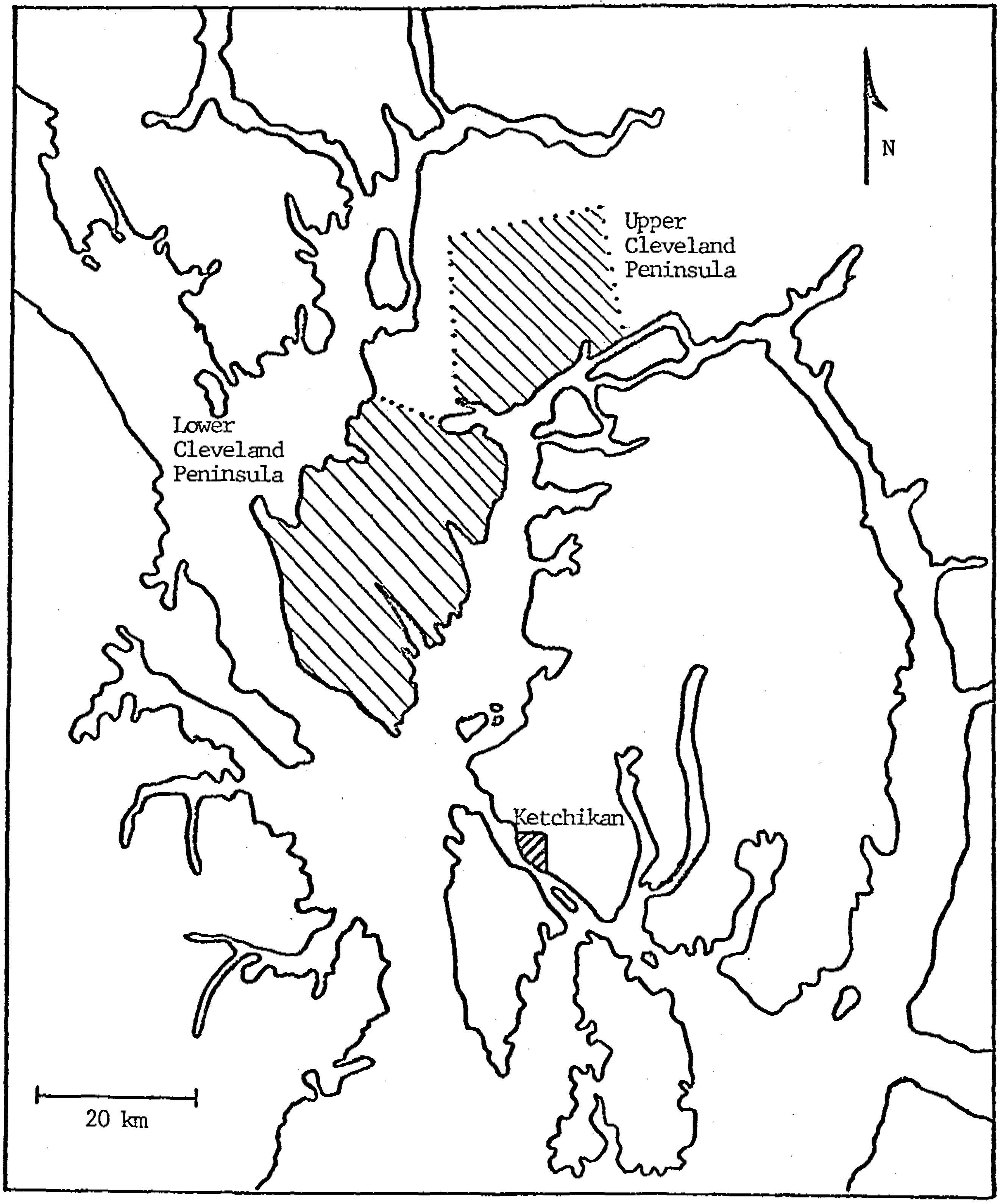


Fig. 1. Location of the Lower and Upper Cleveland Peninsula study areas in relation to Ketchikan, Alaska.

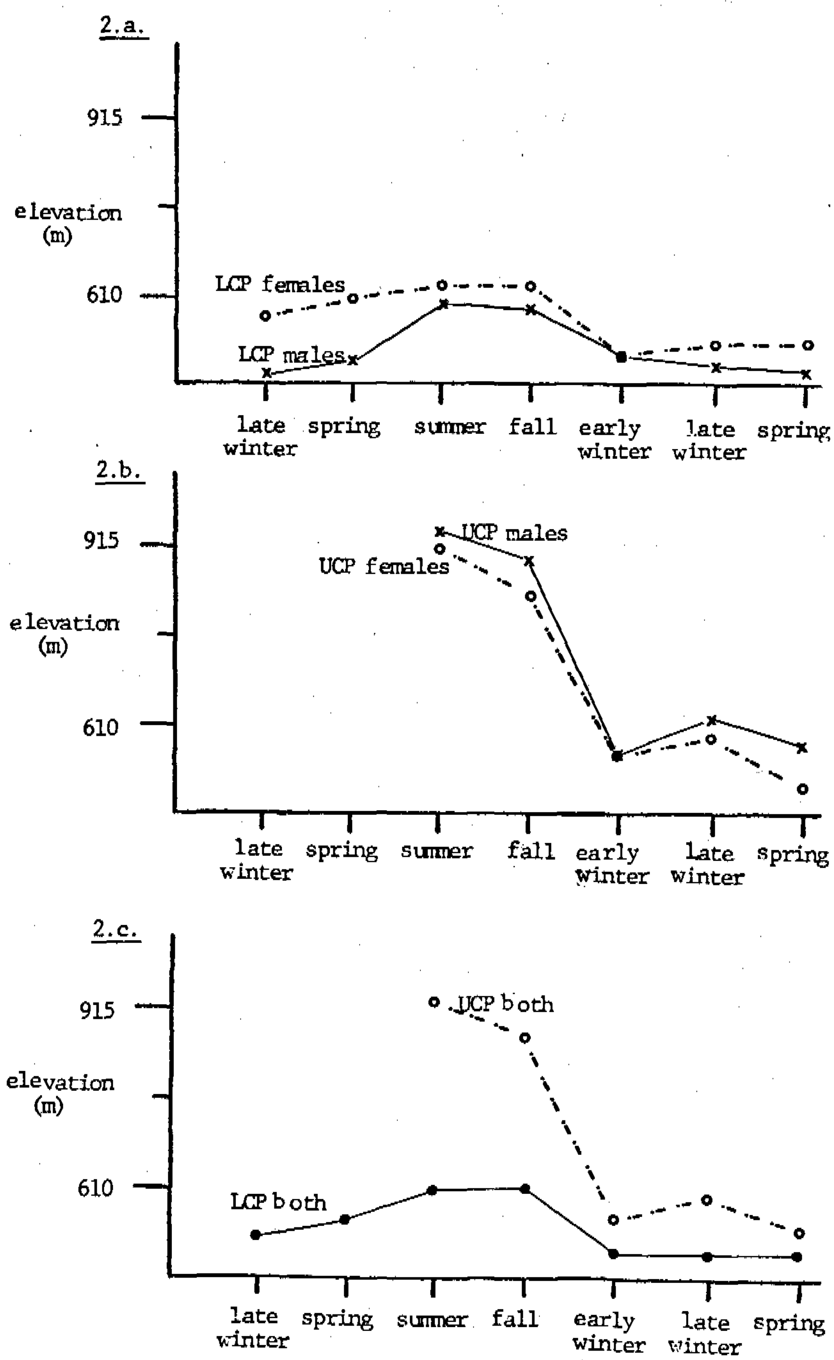


Fig. 2. Changes in elevational use by radio-collared goats from late winter 1980-81 through spring 1982. LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.

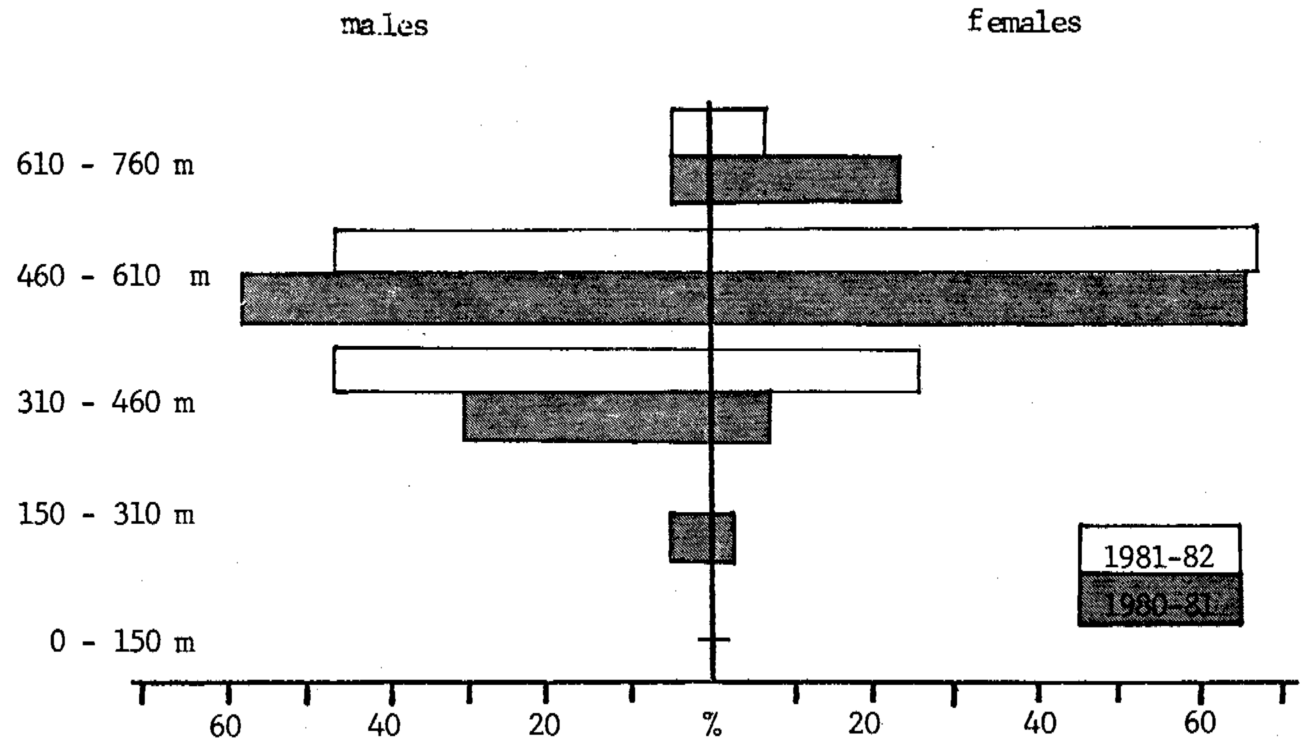


Fig. 3. Frequency of use of elevational zones by goats on the Lower Cleveland Peninsula, late winter 1980-81 and 1981-82.

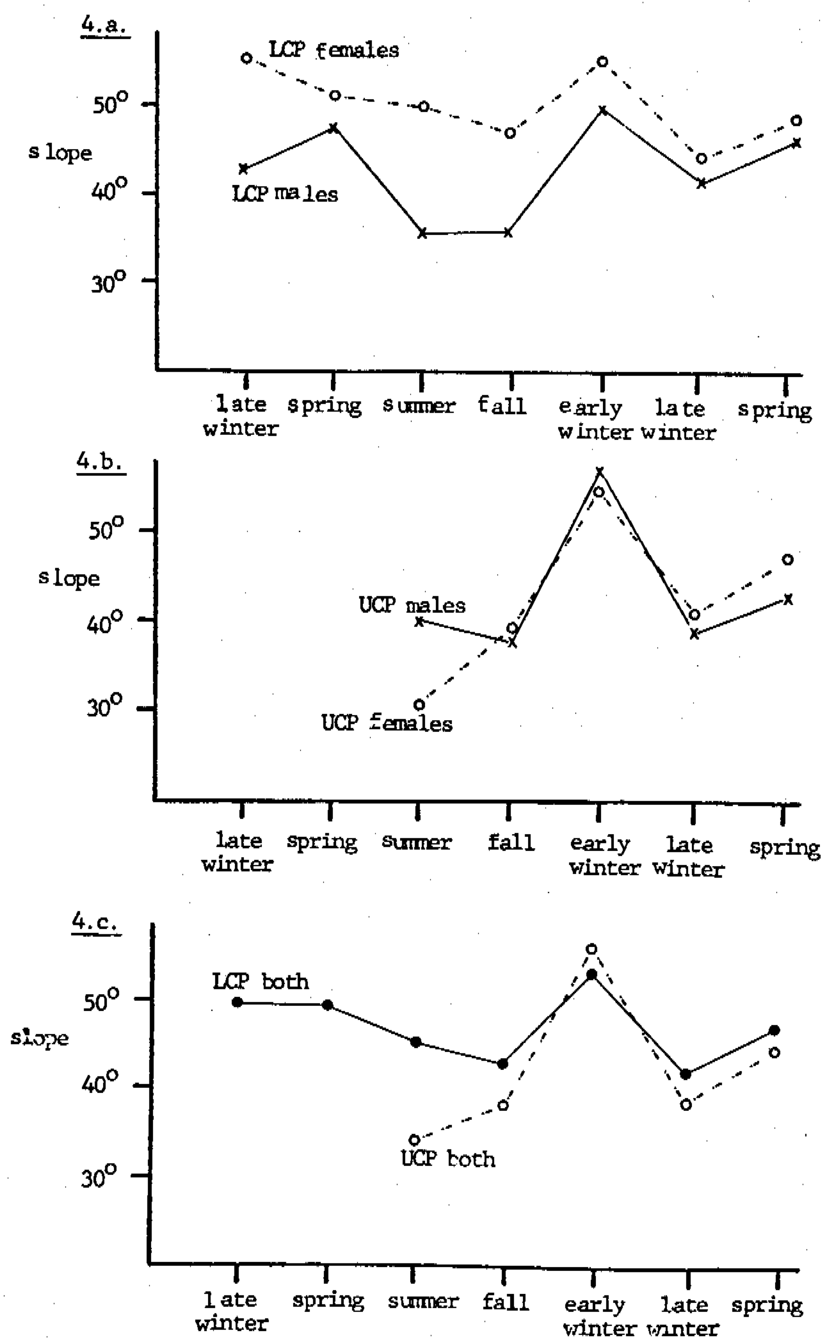


Fig. 4. Seasonal trends in mean slope at goat relocations, late winter 1980-81 through spring 1982. LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.

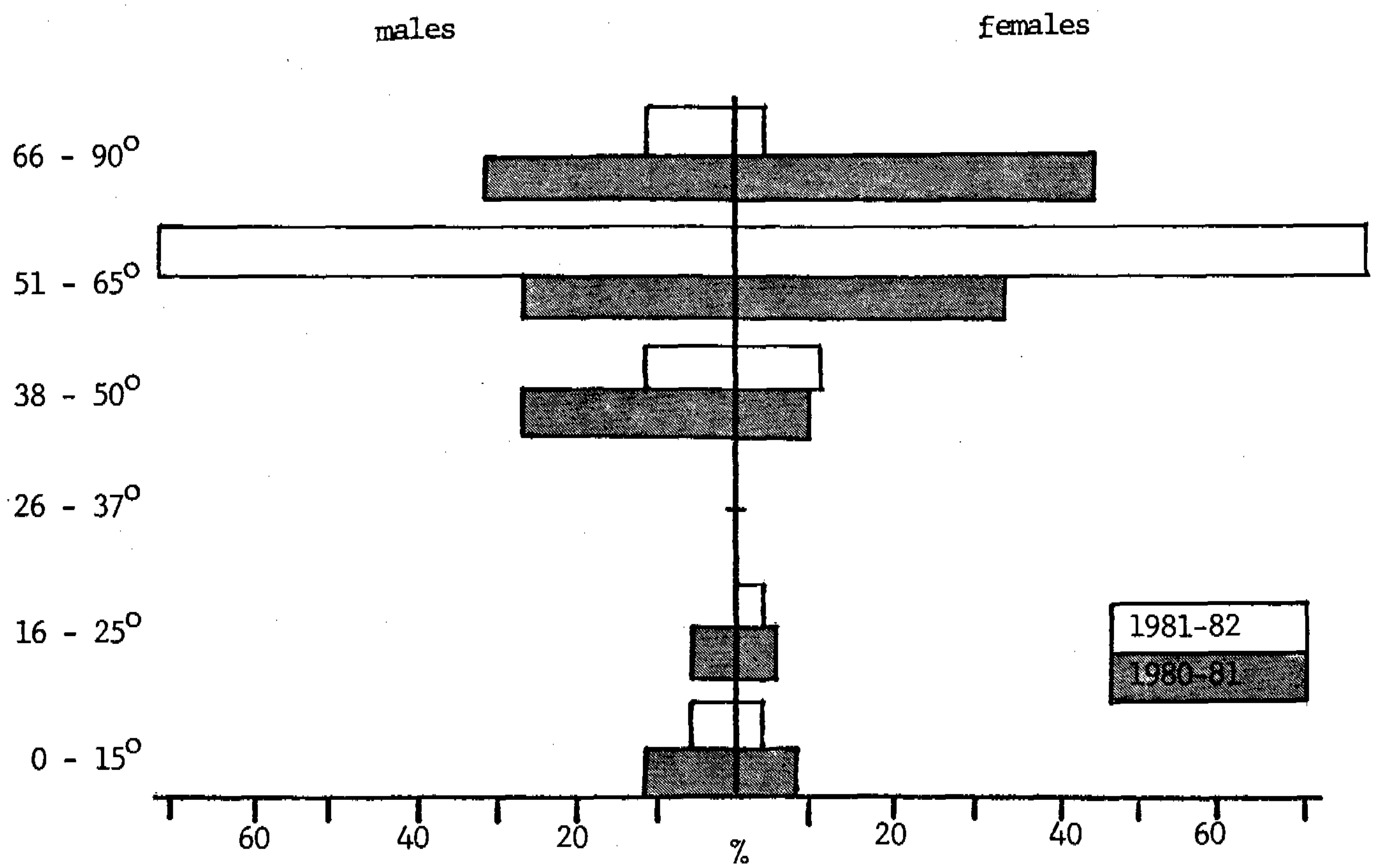


Fig. 5. Frequency of use of slope categories by Cleveland Peninsula goats, late winter 1980-81 and 1981-82.

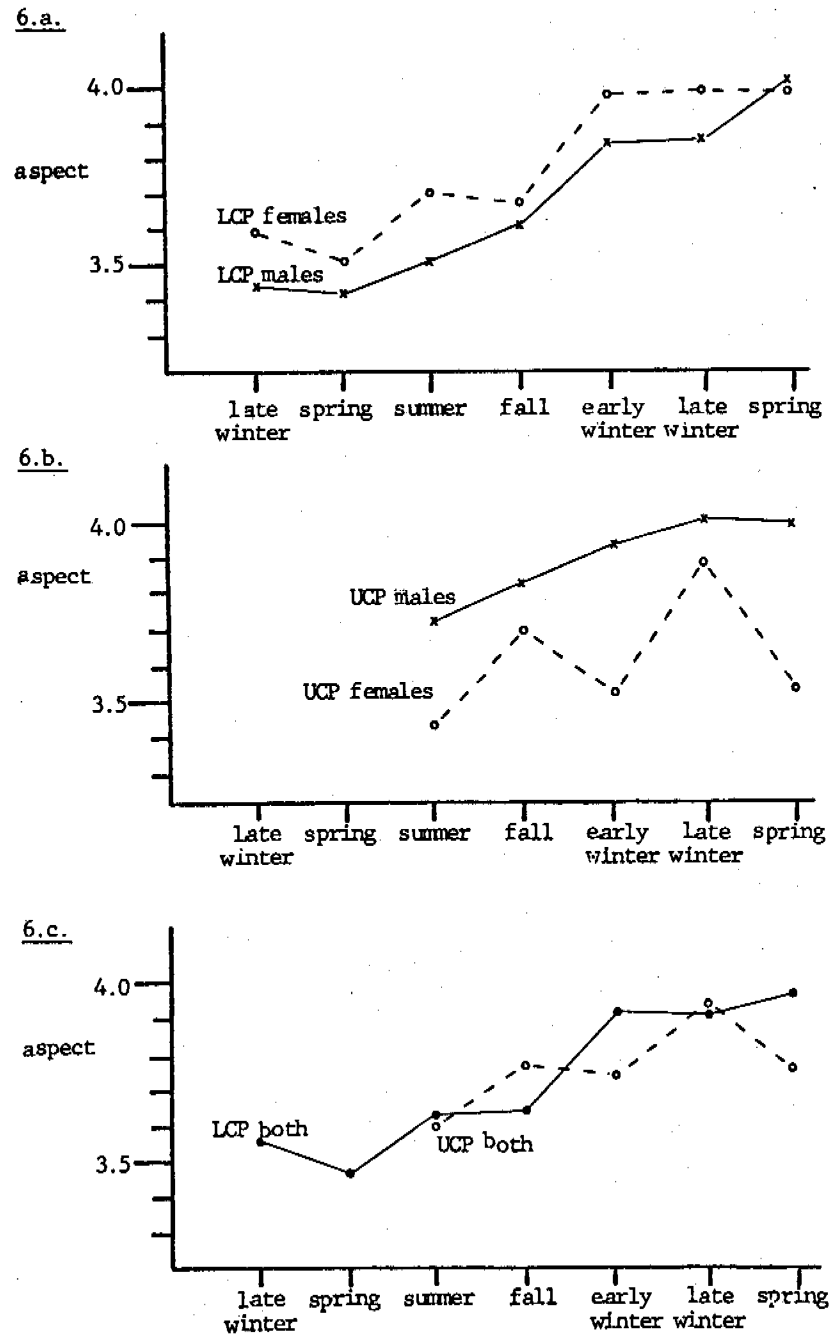


Fig. 6. Seasonal trends in mean aspect (N = 1; NE and NW = 2; E and W = 3; SE and SW = 4; S = 5) at goat relocations, late winter 1980-81 through spring 1982. LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.

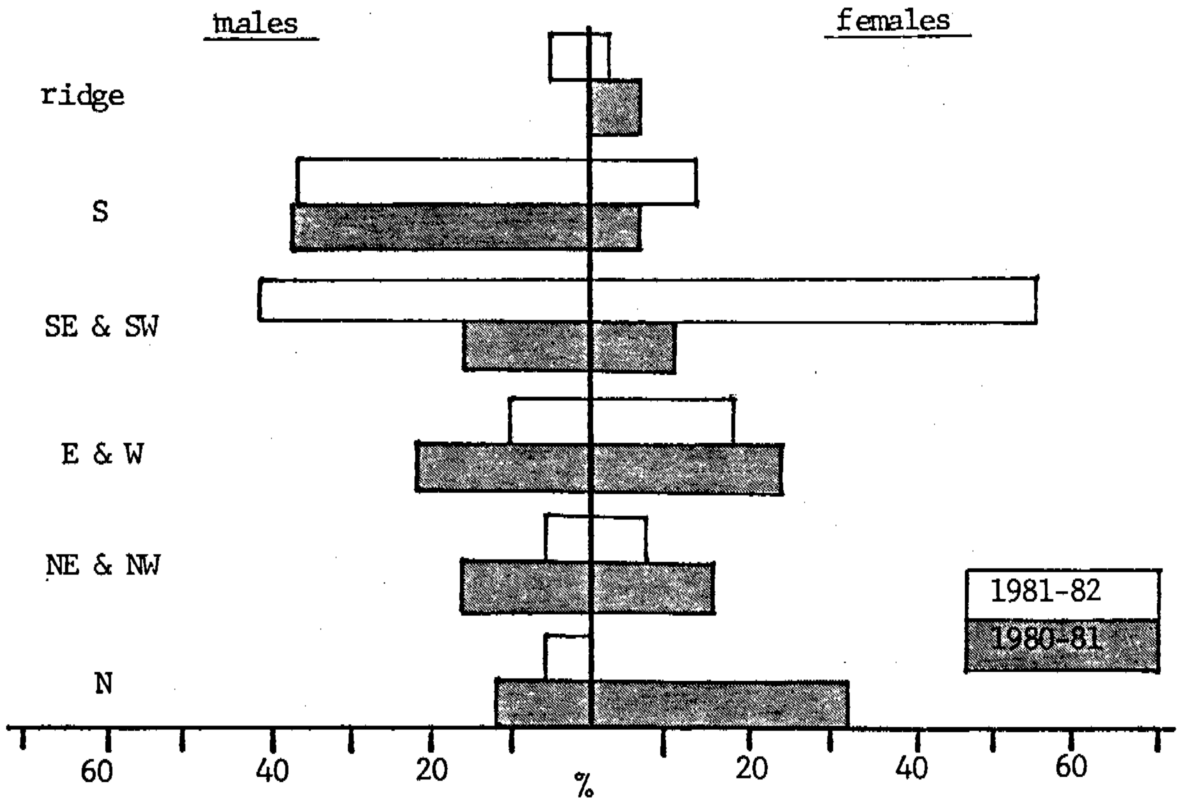


Fig. 7. Frequency of use of aspect categories by Lower Cleveland Peninsula goats, late winter 1980-81 and 1981-82.

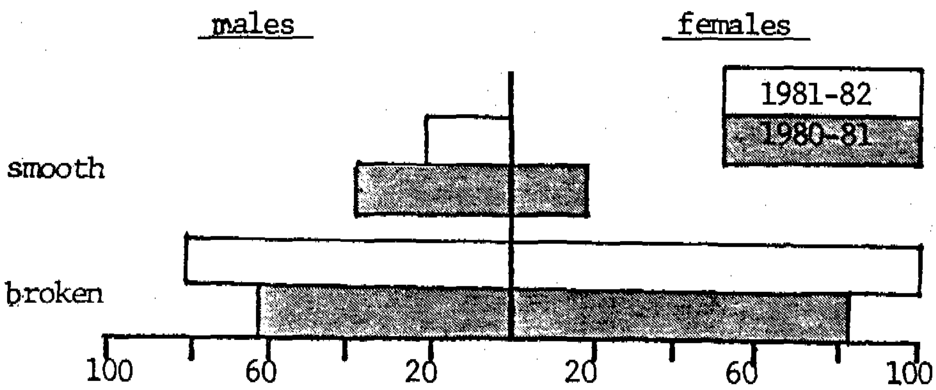


Fig. 8. Frequency of use of terrain types by Lower Cleveland Peninsula goats, late winter 1980-81 and 1981-82.

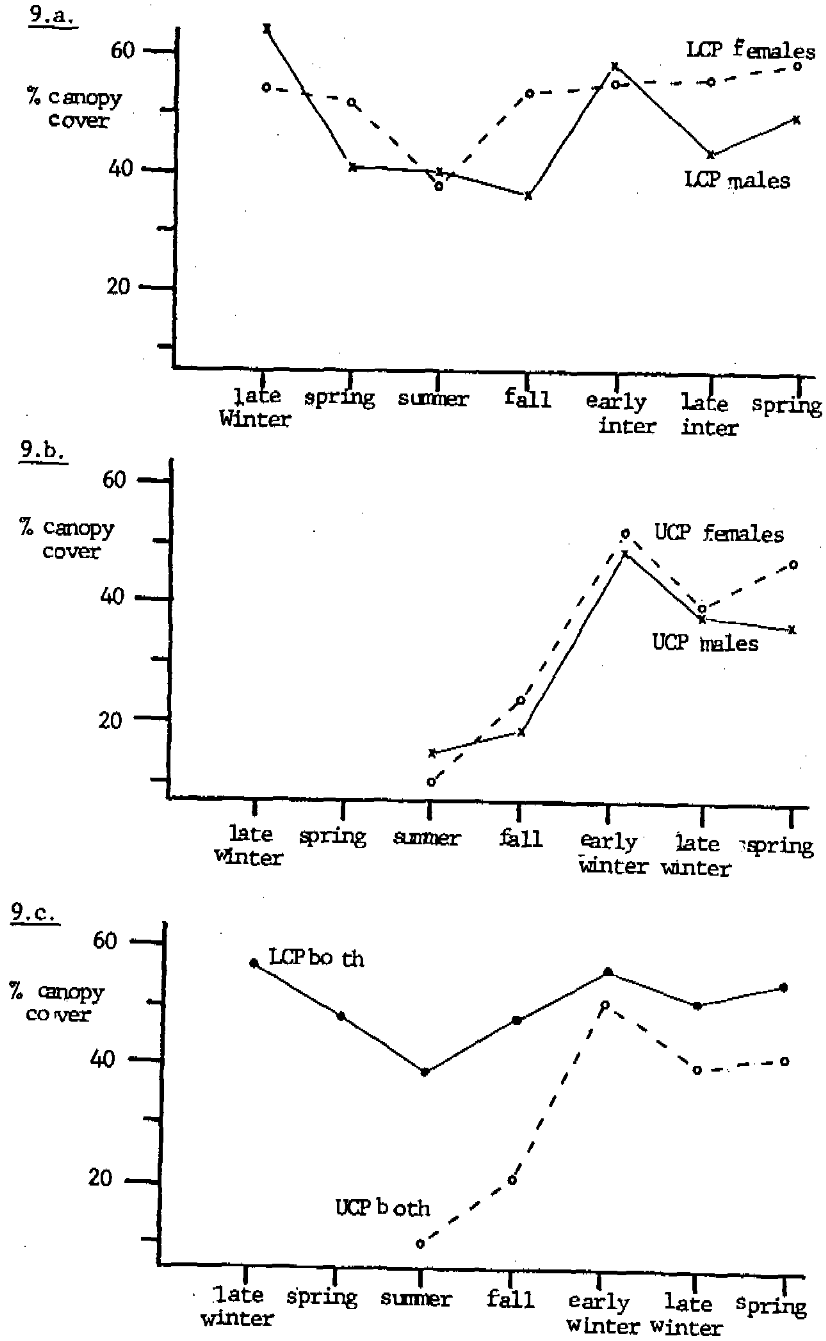


Fig. 9. Seasonal trends in mean percent canopy cover at goat relocations, late winter 1980-81 through spring 1982. LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.

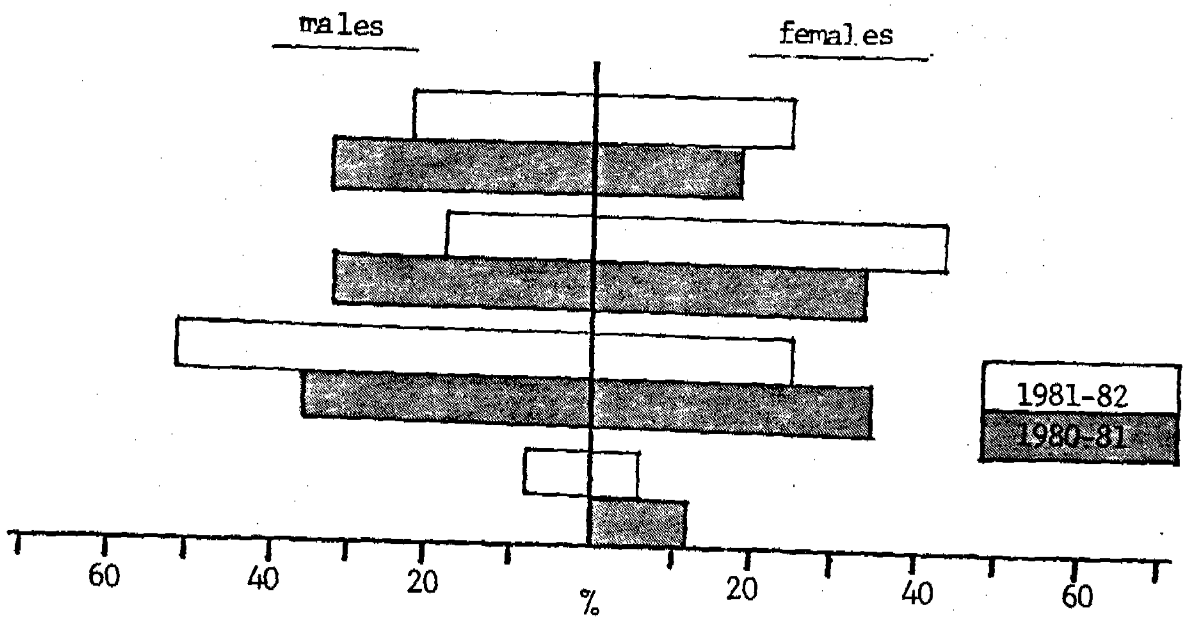


Fig. 10. Frequency of use of canopy cover classes by Lower Cleveland Peninsula goats, late winter 1980-81 and 1981-82.

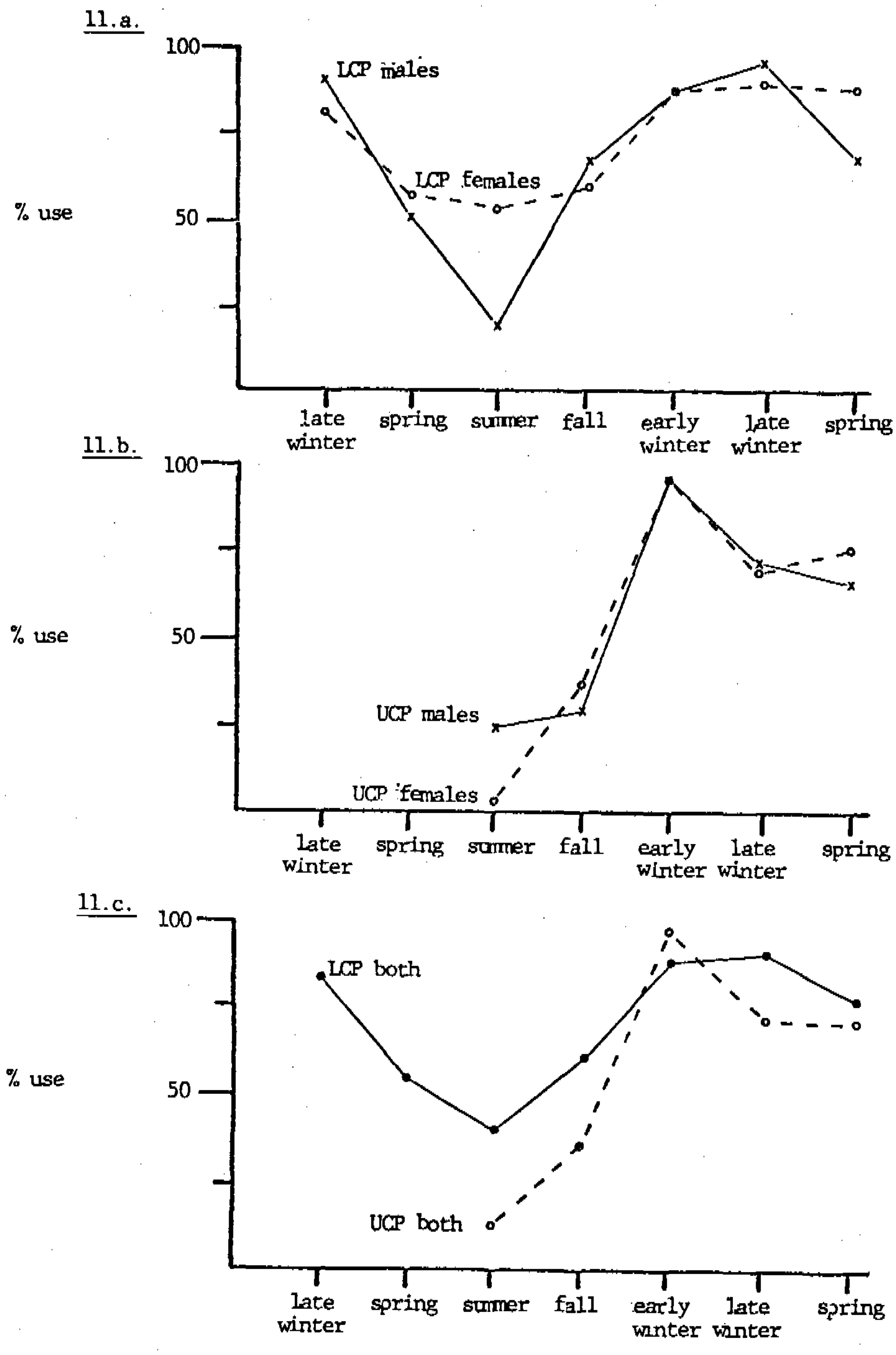
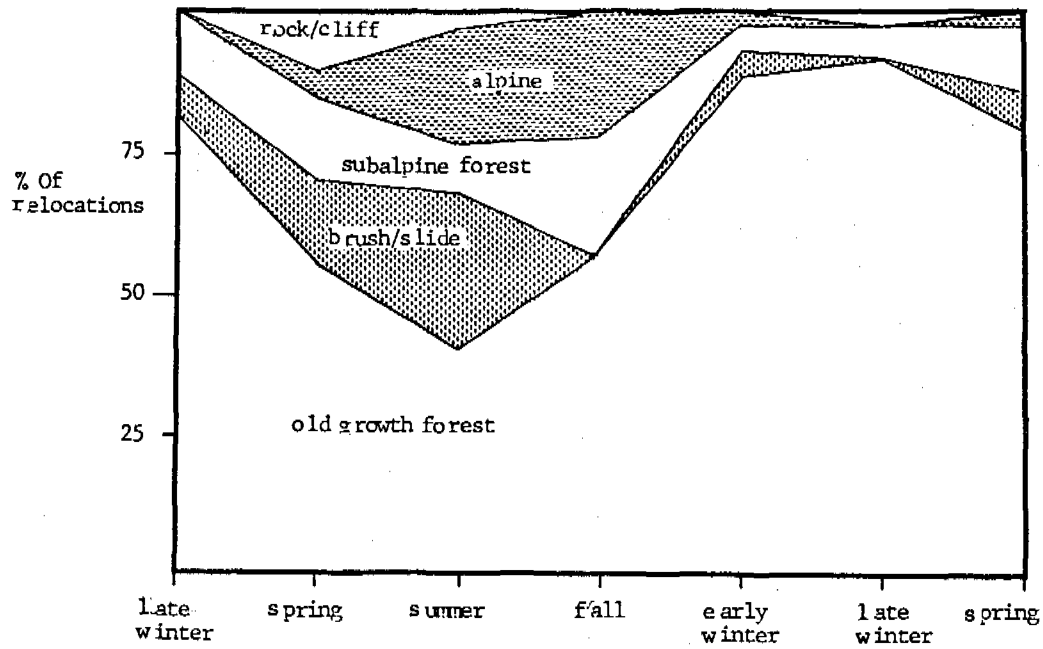


Fig. 11. Seasonal trends in percent use of old growth forest by goats, late winter 1980-81 through spring 1982. LCP = Lower Cleveland Peninaula; UCP = Upper Cleveland Peninsula.

12.a. Lower Cleveland Peninsula



12.b. Upper Cleveland Peninsula

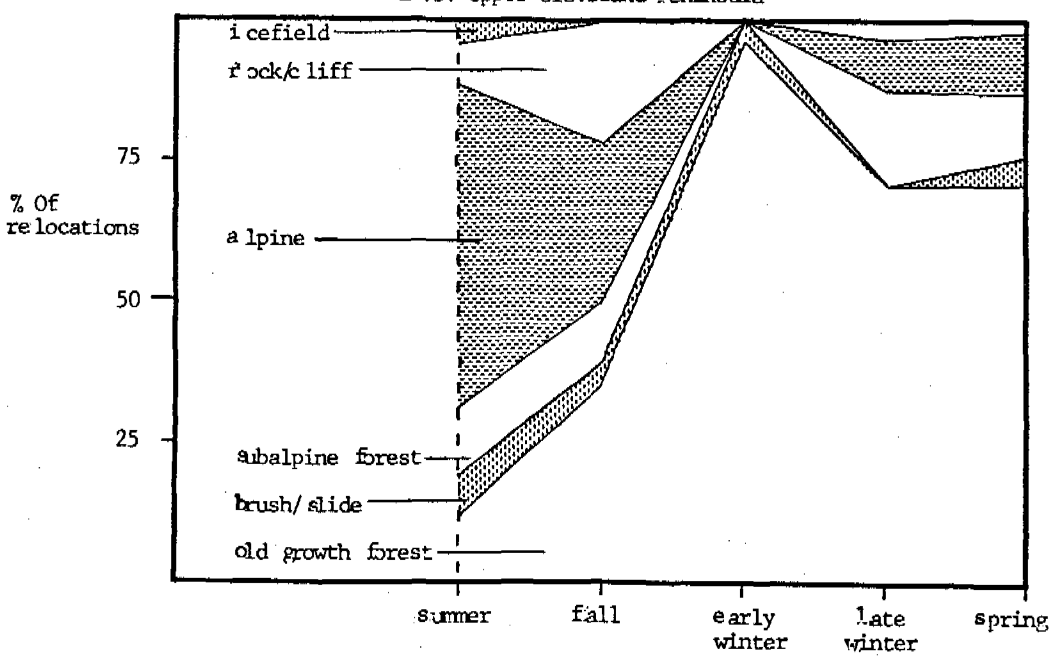


Fig. 12. Seasonal trends in use of vegetation types by goats, late winter 1980-81 through spring 1982.

Table 1. Summary of goat capture results, July 1980-June 1982.

Goat No.	Radio frequency	Study area[a]	Date of capture	Sex	Age	No. of relocations	Status on 30 June 1982
1	150.181	LCP	8/9/80	M	9.2	36	Dead; recovered
2	150.221	LCP	8/9/80	M	2.2	42	Live; transmitting
3	150.291	LCP	8/8/80	F	6.2	38	Dead; recovered
4	150.231	LCP	8/10/80	F	10+	12	Live; transmitting
5	150.162	LCP	8/16/80	F	4.2	41	Live; transmitting
6	150.190	LCP	8/17/80	F	1.2	--	Dead; transmitting
7	150.200	LCP	8/21/80	M	10.2	7	Dead; recovered
8	150.211	LCP	8/21/80	F	4.2	39	Live; transmitting
9	150.150	LCP[b]	8/24/80	F	1.2	35	Live; transmitting
10	150.170	LCP	8/24/80	F	1.2	42	Live; transmitting
11	150.110	UCP	7/9/81	M	2.1	24	Live; transmitting
12	150.350	UCP	7/9/81	M	10.1	24	Live; transmitting
13	150.040	UCP	7/9/81	F	4.1	23	Live; transmitting
14	150.340	UCP	7/10/81	F	6.1	22	Live; transmitting
15	150.090	UCP	7/10/81	F	6.1	16	Live; transmitting
16	150.030	UCP	7/10/81	M	7.1	23	Live; transmitting
17	150.080	UCP	7/10/81	M	2.1	24	Live; transmitting
18	150.310	UCP	7/10/81	F	1.1	23	Live; transmitting
19	150.120	UCP	7/11/81	F	8.1	26	Live; transmitting
20	N/A	UCP	7/11/81	M	8.1	--	Died at capture
21	150.360	UCP	7/11/81	M	1.1	22	Live; transmitting
22	150.101	UCP	7/11/81	M	10.1	23	Dead; recovered
23	150.070	UCP	7/11/81	F	7.1	24	Live; transmitting
24	150.330	UCP	7/11/81	M	1.3	5	Dead; recovered
25	150.370	UCP	7/12/81	M	9.1	24	Live; transmitting
26	150.300	UCP	7/12/81	M	5.1	28	Live; transmitting
27	150.060	LCP	7/28/81	F	10+	7	Dead; recovered
28	150.010	UCP	7/29/81	F	4.1	5	Dead; recovered
29	150.020	UCP	7/31/81	F	7.1	24	Live; transmitting
30[c]	N/A	UCP	7/31/81	F	0.1	--	Unknown
31	N/A	LCP	8/27/81	M	2.3	--	Died at capture
32	150.320	LCP	9/11/81	M	3.3	23	Live; transmitting

[a] LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.

[b] This animal dispersed from the LCP to the UCP study area in June-July 1981.

[c] This animal was the offspring of #29 accidentally captured at the same time.

Table 2. Number of relocations by season and study area.

Study area[a]	Sex	Winter-Spring[b] 1980-81	Summer-Fall[c] 1981	Winter-Spring 1981-82	Total
LCP	M	30	22	56	108
LCP	F	65	40	86	191
LCP	Both	95	62	142	299
UCP	M	--	58	135	193
UCP	F	--	53	133	186
UCP	Both	--	111	268	379
Totals	Both	95	173	410	678

[a] LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.

[b] Winter-Spring = November-May.

[c] Summer-Fall = June-October.

Table 3. Environmental and habitat data associated with radio-collared goats in the study area.

Study area[a]	Sex	Variable	Season: Late winter 1980-81	Spring 1981	Summer 1981	Fall 1981	Early winter 1981-82	Late winter 1981-82	Spring 1982
LCP	Male	Elevation in m	484(22)[b]	505(8)	596(11)	584(6)	514(21)	501(19)	485(13)
LCP	Male	Slope in degrees	42(22)	48(6)	36(10)	36(6)	49(21)	42(18)	46(13)
LCP	Male	Aspect[c]	5(21)	4(8)	5(100)	5(5)	5(21)	5(21)	5(14)
LCP	Male	Canopy cover in %	64(22)	40(6)	40(11)	37(6)	58(18)	44(18)	49(12)
LCP	Male	Broken terrain in %	63(19)	100(8)	90(10)	86(7)	90(20)	80(18)	93(14)
LCP	Female	Elevation	573(48)	601(14)	620(23)	638(13)	415(30)	518(31)	536(26)
LCP	Female	Slope	54(48)	51(14)	50(21)	47(12)	56(30)	42(29)	47(27)
LCP	Female	Aspect	5(44)	5(12)	5(20)	5(12)	5(30)	5(31)	5(28)
LCP	Female	Canopy cover	54(46)	52(14)	39(21)	53(12)	54(27)	55(27)	58(21)
LCP	Female	Broken terrain	83(48)	79(14)	86(21)	67(12)	93(30)	100(30)	100(27)
LCP	Both	Elevation	545(70)	566(22)	612(34)	621(19)	514(51)	512(50)	513(39)
LCP	Both	Slope	50(70)	50(20)	45(31)	43(18)	53(51)	42(47)	47(40)
LCP	Both	Aspect	5(65)	5(19)	5(30)	5(17)	5(51)	5(52)	5(42)
LCP	Both	Canopy cover	57(68)	48(20)	39(32)	48(18)	56(45)	51(45)	55(53)
LCP	Both	Broken terrain	78(67)	86(22)	87(31)	74(19)	92(50)	96(48)	98(41)
UCP	Male	Elevation	--	--	936(38)	894(12)	561(33)	619(48)	579(54)
UCP	Male	Slope	--	--	40(37)	38(13)	57(32)	38(46)	42(54)
UCP	Male	Aspect	--	--	5(38)	5(11)	5(34)	5(46)	5(50)
UCP	Male	Canopy cover	--	--	14(37)	19(13)	49(26)	39(43)	37(46)
UCP	Male	Broken terrain	--	--	100(38)	100(13)	100(35)	92(48)	96(54)
UCP	Female	Elevation	--	--	932(34)	845(15)	550(33)	595(47)	513(54)
UCP	Female	Slope	--	--	30(34)	39(15)	56(33)	40(46)	47(53)
UCP	Female	Aspect	--	--	5(28)	5(13)	5(31)	5(44)	6(54)
UCP	Female	Canopy cover	--	--	6(33)	23(15)	53(28)	40(46)	48(50)

Table 3. Continued.

Study area[a]	Sex	Variable	Late winter 1980-81	Spring 1981	Summer 1981	Fall 1981	Early winter 1981-82	Late winter 1981-82	Spring 1982
			Season						
UCP	Female	Broken terrain	--	--	100(35)	100(15)	94(33)	98(47)	100(56)
UCP	Both	Elevation	--	--	934(72)	867(27)	555(66)	607(95)	546(108)
UCP	Both	Slope	--	--	35(72)	39(28)	56(63)	39(92)	45(107)
UCP	Both	Aspect	--	--	5(66)	5(24)	5(65)	5(90)	5(104)
UCP	Both	Canopy cover	--	--	10(70)	21(28)	51(54)	40(89)	42(96)
UCP	Both	Broken terrain	--	--	100(73)	100(28)	97(70)	95(95)	98(110)

[a] LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.
[b] Number of relocations.
[c] Aspect: 1 = Flats; 2 = N; 3 = NE and NW; 4 = E and W; 5 = SW and SE; 6 = S.

Table 4. Percent use of vegetation types on both study areas by season and sex.

Study area[a]	Sex	Vegetation	Season: Late winter 1980-81	Spring 1981	Summer 1981	Fall 1981	Early winter 1981-82	Late winter 1981-82	Spring 1982
LCP	Male	OGF[b]	89.5	50.0	18.2	66.7	88.2	94.4	66.7
		B/S[c]	0.0	16.7	36.4	0.0	5.9	0.0	16.7
		SF[d]	10.5	0.0	18.2	16.7	5.9	5.6	16.7
		A[e]	0.0	16.7	27.3	16.7	0.0	0.0	0.0
		R/C[f]	0.0	16.7	0.0	0.0	0.0	0.0	0.0
		(N)[g]	(19)	(6)	(11)	(6)	(17)	(18)	(12)
LCP	Female	OGF	80.0	57.1	52.4	58.3	88.0	89.3	85.7
		B/S	10.0	14.3	23.8	0.0	0.0	0.0	0.0
		SF	10.0	21.4	0.0	16.7	8.0	7.1	9.5
		A	0.0	0.0	19.1	25.0	4.0	0.0	4.8
		R/C	0.0	7.1	4.8	0.0	0.0	3.6	0.0
		(N)	(40)	(14)	(21)	(12)	(25)	(28)	(21)
LCP	Both	OGF	83.1	55.0	40.6	61.1	88.1	91.3	78.8
		B/S	6.8	15.0	28.1	0.0	2.4	0.0	6.1
		SF	10.20	15.0	6.3	16.7	7.1	6.5	12.1
		A	0.0	5.0	21.9	22.2	2.4	0.0	3.0
		R/C	0.0	10.0	3.1	0.0	0.0	2.2	0.0
LCP	Both	(N)	(59)	(20)	(32)	(18)	(42)	(46)	(33)
	Male	OGF	--	--	25.0	30.8	95.7	72.1	65.2
		B/S	--	--	2.8	0.0	4.3	0.0	4.4
		SF	--	--	8.3	15.4	0.0	16.3	15.2
		A	--	--	50.0	38.5	0.0	7.0	10.9
		R/C	--	--	5.6	15.4	0.0	4.7	4.4
		IF[h]	--	--	8.3	0.0	0.0	0.0	0.0
		(N)	--	--	(36)	(13)	(23)	(43)	(46)
UCP	Female	OGF	--	--	3.1	40.0	96.4	69.6	76.0
		B/S	--	--	6.3	6.7	3.6	0.0	6.0
		SF	--	--	15.6	6.7	0.0	17.4	6.0
		A	--	--	65.6	20.0	0.0	10.9	12.0
		R/C	--	--	9.4	26.7	0.0	2.2	0.0
		IF	--	--	0.0	0.0	0.0	0.0	0.0
		(N)	--	--	(32)	(15)	(28)	(46)	(50)

Table 4. Continued.

Study Area[a]	Sex	Vegetation	Season: Late winter 1980-81	Spring 1981	Summer 1981	Fall 1981	Early winter 1981-82	Late winter 1981-82	Spring 1982
UCP	Both	OGF	--	--	14.7	35.7	96.1	70.8	70.8
		B/S	--	--	4.4	3.6	3.9	0.0	5.2
		SF	--	--	11.8	10.7	0.0	16.9	10.4
UCP	Both	A	--	--	57.4	28.6	0.0	9.0	11.5
		R/C	--	--	7.4	21.4	0.0	3.4	2.1
		IF	--	--	4.4	0.0	0.0	0.0	0.0
		(N)	--	--	(68)	(28)	(51)	(89)	(96)

[a] LCP = Lower Cleveland Peninsula; UCP = Upper Cleveland Peninsula.
[b] OGF = Old Growth Forest.
[c] B/S = Brush/Slide.
[d] SF = Subalpine Forest.
[e] A = Alpine (including Krummholz).
[f] R/C = Rock/Cliff.
[g] (N) = Sample size.
[h] IF = Icefield.

Table 5. Frequency distributions for habitat parameters of grid cells sampled and used by goats on the UCP, 1981-82.

Variable	Available (N = 1,527)	Used[a] (N = 81)	Unused[a] (N = 1,446)	Used[b] (N = 277)
Elevation				
0-150 m	14.0	0.0	14.7	1.1
150-300 m	14.9	16.1	14.9	3.6
300-460 m	19.7	27.2	19.3	21.2
460-610 m	16.3	19.8	16.1	17.9
610-760 m	16.0	16.1	16.0	19.0
760-910 m	11.9	13.6	11.8	19.3
910-1,070 m	5.1	7.4	5.0	11.7
1,070-1,220 m	1.8	0.0	1.9	6.2
1,220-1,370 m	0.3	0.0	0.3	0.0
Slope				
0-15°	29.7	17.3	30.4	7.6
16-20°	4.7	1.2	4.9	0.4
21-25°	8.5	6.2	8.6	2.9
26-30°	21.7	17.3	22.0	9.4
31-37°	17.2	22.2	16.9	28.5
38-50°	11.5	17.3	10.9	26.0
51-65°	5.3	14.8	4.8	19.1
66°	1.6	3.7	1.5	6.1
Aspect				
Flat	14.0	1.2	14.7	1.1
N	6.4	2.3	6.6	3.3
NE/NW	19.8	11.1	20.2	14.8
E/W	20.6	7.4	21.3	12.6
SE/SW	27.6	51.9	26.3	50.5
S	9.8	21.0	9.2	17.3
Ridge	1.8	5.9	1.6	0.4
Distance to cliff				
d = 0	6.9	18.5	6.2	1.4
d < 0.4 km	49.6	71.6	48.3	91.0
0.4 < d < 0.8 km	20.0	6.3	30.8	6.5
0.8 < d < 1.2 km	9.4	2.5	9.8	0.4
1.2 < d < 1.6 km	6.5	1.2	6.8	0.4
1.6 < d < 2.0 km	3.3	0.0	3.5	0.4
2.0 < d < 2.4 km	2.0	0.0	2.1	0.0
2.4 < d < 2.8 km	2.0	0.0	2.1	0.0

Table 5. Continued.

Variable	Available (N = 1,527)	Used[a] (N = 81)	Unused[a] (N = 1,446)	Used[b] (N = 277)
Vegetation				
OGF[c]	32.4	44.5	31.6	33.6
FC[d]	2.9	1.2	2.8	6.9
MF[e]	10.8	2.4	11.3	1.1
SF[f]	23.4	24.7	23.2	23.1
B/S[g]	4.9	2.4	5.0	2.1
R/C[h]	12.6	14.8	12.5	16.3
Alpine	5.8	10.0	5.5	16.6
Muskeg	0.5	0.0	0.6	0.0
Other	7.0	0.0	7.4	0.4
Timber volume				
0	30.3	27.2	30.5	35.0
<8 MBF/A	36.9	28.4	27.4	31.8
8-20 MBF/A	16.6	23.5	16.3	11.9
20-30 MBF/A	14.7	16.1	14.6	19.5
30-50 MBF/A	1.4	4/9	1.2	1.8
50 MBF/A	0.0	0.0	0.0	0.0

[a] Cells out of 1,527 random sample.
[b] All cells used by radio-collared goats.
[c] OGF = Old Growth Forest.
[d] FC = Forested Cliff.
[e] MF = Muskeg Forest.
[f] SF = Subalpine Forest.
[g] B/S = Brush/Slide.
[h] R/C = Rock/Cliff.

Table 6. Chi-squared values for comparison of used, unused, and available cells on UCP study area, 1981-82.

Variable	Used[a] vs. available[c]	Used[b] vs. available	Used vs. unused[d]	Unused vs. available	Degrees of freedom
Elevation	21.08*	45.49*	22.51*	0.05	8
Aspect[e]	45.78*	24.93*	52.27*	0.17	4
Slope	33.72*	106.18*	39.69*	0.52	7
Distance to cliff	55.97*	69.44*	64.24*	0.21	8
Vegetation	24.59*	89.41*	27.00*	0.65	11
Timber volume	14.03*	4.35	17.27*	0.04	4

[a] Cells used out of random sample of 1,527.
[b] Based on 1,527 randomly sampled cells.
[c] All cells used by radioed goats; N = 277.
[d] Cells in random sample of 1,527 not used by radioed goats; N = 1,250.
[e] Based on a north-to-south continuum.
* Significant at $P < 0.05$.

Table 7. Chi-squared values for used[a] versus available[b] cells on UCP study area by elevational zones.

Elevation (ft)	Aspect[c]	Slope	Distance to cliff	Vegetation	Timber volume
0-500	169.6(5)[d]*	1,195.3(7)*	457.8(8)*	50.0(3)	115.39(4)*
501-1,000	115.7(6)*	267.0(7)*	55.4(8)*	21.8(4)*	21.6(4)*
1,001-1,500	50.4(6)*	151.7(7)*	84.1(8)*	49.1(6)*	92.1(4)*
1,501-2,000	47.5(6)*	106.7(7)*	60.7(7)*	15.8(7)*	123.4(4)*
2,001-2,500	19.0(6)*	96.5(7)*	24.8(3)*	24.0(6)*	12.6(3)*
2,501-3,000	47.8(6)*	61.1(7)*	18.1(4)*	30.6(6)*	8.1(2)*
3,001-3,500	80.1(6)*	70.3(7)*	19.0(2)*	33.9(3)*	42.7(1)*
3,501-4,000	61.5(5)*	27.1(4)*	8.0(1)*	0.0(1)	

[a] All cells used by radioed goats; N = 277.
[b] Based on random sample of 1,527 cells.
[c] Based on a north-to-south continuum.
[d] Number in ( ) is degrees of freedom.
* Significant at $P < 0.05$.

APPENDIX A.

MOUNTAIN GOAT ECOLOGY ON CLEVELAND PENINSULA, ALASKA 1980-1982

J. L. Fox, K. J. Raedeke, & C. A. Smith

FINAL REPORT TO:

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FORESTRY SCIENCES LABORATORY
JUNEAU, ALASKA

IN FULFILLMENT OF:

COOPERATIVE AGREEMENT NO. PNW-81-0017

FINAL REPORT TO: Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 909
Juneau, Alaska 99802

CONTRACT: PNW-82-197

MOUNTAIN GOAT ECOLOGY ON CLEVELAND PENINSULA, ALASKA

1980-1982

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BACKGROUND

The Five-Year Action Plan for timber harvest on the Ketchikan Area, Tongass National Forest, includes preparation for logging on the Cleveland Peninsula. The Tongass National Forest and the Pacific Northwest Forest and Range Experiment Station initiated a study on mountain goat habitat use on the Cleveland Peninsula (Harrington 1979, Raedeke 1980) with the ultimate goal of mitigating any potential detrimental effects that logging activities may have on the goat population. The area of concern is, on first view, rather atypical goat habitat comprised of some 200 square miles of relatively low elevation and predominately forest land (highest point--3200 feet). However, the area supports at least 50 mountain goats (Raedeke 1980) and is identified as an important goat area in terms of recreational hunting and viewing (USFS 1979). There is very little alpine habitat on the peninsula. The goats were thought to make significant use of forested habitats, which made apparent the need to identify any potential conflict in forest use between goats and logging operations.

The present study was initiated in the summer of 1980 with a ground census of goats on the lower Cleveland Peninsula and the capture and radio-collaring of 10 goats for subsequent radio-tracking (Raedeke 1980). Fixed-wing flights to locate these goats on a regular basis have been carried out by the Alaska Department of Fish and Game. Smith (1981) provided an initial report on winter goat habitat selection based on aerial observation of the habitat attributes of radioed-goat locations obtained during the winter of 1980-1981. Preliminary results describing goat habitat use based on map-derived habitat characteristics and mapped radio-location of goats were prepared by Fox and Raedeke (1982). The present report is a final presentation of the results for this study.

Study Objectives:

1. Determine winter and spring distribution of goats on the entire study area on the Cleveland Peninsula.

2. Characterize preferred winter goat habitat in terms of biotic and abiotic environmental parameters.

3. Determine which environmental parameters, biotic and abiotic are most important in influencing habitat selection and in limiting winter habitat use by mountain goats on the peninsula.

4. Continue field observations of grazing use of plants by goats, and fecal collections to describe major plant species in the goat diet.

5. Delineate preferred and potential mountain goat winter range on the entire study area on the Cleveland Peninsula.

Parallel studies of winter goat habitat use have recently been completed in study sites near Juneau (Fox and Taber 1981; Schoen, Kirchoff, Wallmo, Fox and Taber 1982). Results of these studies indicate a descending order of importance for "escape" terrain, forage availability and thermoregulatory behavior in goat habitat selection during winter and demonstrate the marked effect of snow on the availability of forage in various plant communities. Conclusions by Fox and Taber (1981) suggested that critical goat winter range could be defined as areas within 500m of steep and broken "escape" terrain with utilization of these areas being related to available forage as determined by the plant communities present and the current snow conditions. Potential for extrapolation and prediction to the Cleveland Peninsula based on results of the Juneau study is obvious and provides a forum for testing some of the conclusions. Determination of available forage in the Juneau study has relied on identification of the array of plant communities present within the study area (Fox and Taber 1981), the result of which is outlined with brief descriptions in Appendix I. Extrapolation of forage availability data derived from the Juneau study to habitats on the Cleveland Peninsula depends on the existence of similar plant communities and comparable forage biomass, so that part of the present study also involved reconnaissance of these attributes.

The results of this reconnaissance (Fox and Raedeke 1982) are outlined in the present report and indicate that comparable plant communities are present in both study areas, although in different relative abundances. Based on the relationships of relative snow deposition and melt to various habitat characteristics and their ultimate relationship to available forage (Fox and Taber 1981) hypotheses concerning goat habitat use as related to winter snow regime are conceivable. On the lower Cleveland Peninsula where windswept alpine habitats (which can provide winter forage) are virtually non-existent, remaining habitat characteristics which correlate with diminished relative snow depth, and hence increased forage, are likely to be selected to a greater extent during winters with heavy snowfall. Such habitat characteristics include low elevation, steep slopes, southerly aspects, and greater tree canopy coverage (timber volume). In addition, increased travel energy expenditures with greater snow depth should dictate decreased movement by goats away from escape terrain when snow pack is deep. Recognizing that the .01 sq mi resolution of radio-tracking and map-grid locations in the present study precludes highly detailed habitat use predictions we can still expect predictable trends in the goat use of habitat characteristics.

In essence then, goats on the Cleveland Peninsula should generally remain within 500m of steep and broken escape terrain during winter. However, within this area of access to escape terrain in a winter of relatively heavy snowfall the goats on lower Cleveland Peninsula should select habitats of a) lower elevation, b) steeper slope, c) more southerly aspect, d) less distance from cliffs and e) greater timber volume than they would in a winter with less snowfall. The past two winters of light and heavy snowfall respectively provide the natural experiment for testing these hypotheses. We should then be in a position to determine if significant weather (snowfall) related differences in goat habitat selection need be considered in the planning for mitigation of human impacts on the Cleveland Peninsula goat population.

METHODS

Ground-Based Data

A site on the southwest end of the Cleveland Peninsula was selected for the ground-based winter investigations. The site is a generally east and south-east facing steep hillside adjacent to Bear Lake and was selected due to the presence there of the largest group of goats on the lower peninsula, a satisfactory winter camping site and the access to negotiable goat winter habitat (Fig. 1). During the winter of 1980-1981 three trips (28 Nov - 1 Dec, 28 Dec - 3 Jan, 20-23 Feb) and in the winter of 1981-1982 five trips (20-22 Nov, 8-10 Dec, 17-19 Jan, 21-23 Feb, 14-16 March) were made to this Bear Lake study site, each yielding data on snow conditions, food habits and fecal pellet collections. An additional trip to Bear Lake (4-9 June 1981) provided data on plant communities and forage biomass in the study area. Reconnaissance of several goat wintering sites in two other areas on the lower peninsula (Stump Lake, 13-16 June 1981 and Port Stewart, 17 June 1981) provided additional information on plant communities, forage biomass and goat food habits.

Snow Conditions

In the vicinity of the Bear Lake study site snow depth measurements were made at elevations of 500 ft, 1150 ft, 2300 ft and 2600 ft during each of the eight ground visits. The three lower elevation sites were in open sites relatively protected from wind while the highest elevation

Figure 1. Study area on lower Cleveland Peninsula. Arrow points to Bear Lake study site.

was on a ridgetop exposed to wind redistribution of snow. The snow measurements consisted of reading depth from a snow stake permanently placed at each of the sampling locations.

Plant Communities and Forage Biomass

Subjective assessment of the presence and extent of various plant communities (Appendix I), recognized by dominant species and plant structure, was carried out through extensive travel during over-flights of the peninsula and on the several visits to the lower peninsula in June 1981. Several biomass measurements were made in selected representative stands of *Vaccinium* Forest and Subalpine Forest communities. Shrub, forb and conifer components of the forest understory within the foraging height of goats ($\leq$ 150 cm above ground surface) were measured. Forage biomass of shrubs was estimated by measuring basal diameter of all shrub stems within 10 m x 25 cm plots arranged consecutively along a belt transect within the selected stand. Basal diameter was converted to current annual growth of twigs (winter forage) using regressions derived by Alaback (1981) for species in Southeast Alaska. Conifer current annual growth within a plot was collected and later dried and weighed for biomass determination. Forb biomass was derived from percentage cover estimates within 20 x 50 cm quadrats located randomly along the belt transect described above. Percentage cover of forbs was converted to forage biomass using regression derived for species present in the Juneau study (Fox, unpublished data). Three transects were run in *Vaccinium* Forest and two in Subalpine Forest though all understory components were not measured in each case.

Winter Food Habits

Recent goat fecal pellets were collected during each of the winter visits to the Bear Lake study site. Five pellets from each of at least 20 pellet groups were collected to form a sample "diet." The collection of pellets during each visit will constitute one "diet" particular to the seasonal and snow characteristics present at that time. Species composition determination of the contents of each "diet" are to be determined by microhistological analysis under contract to an appropriate laboratory. Incidental observations of evidence indicating goat feeding on plant species was also collected during the various visits to sites on the lower Cleveland Peninsula.

Habitat Mapping & Radio-Tracking Data

Available habitat

A portion of the lower Cleveland Peninsula was selected as representative of the entire area and used for intensive analysis. The site chosen is an approximately 100 sq mi area situated south of a line defined by the lowest elevation traverse between Union Bay and Helm Bay (Fig. 1). This 100 sq mi area was sectioned on a 1:31680 scale map into approximately 10,200 grid squares, each representing an area of 0.01 sq mi. A systematic sample of alternate grid intersections produced a sample size of 2548 points evenly spread over the area. Each grid intersection (or point) identified the grid square of which it formed the southwest corner. At each sample point representative habitat data were taken from maps. Elevation, slope, aspect and distance from cliffs were taken from USGS

1:63360 scale maps which had been blown up to a scale of 1:31680. Slope was measured by taking the shortest distance between the two 100 ft contour lines adjacent to the grid point in question. Distance intervals of 1/60 inch were used and converted by trigonometry to the slope intervals given in Appendix II. Distance from cliffs was obtained by identifying all areas with greater than 50° slope as "cliffs" and measuring the distance to the border of the nearest "cliff" area. From USFS 1:31680 scale timber-type maps, vegetation type (using USFS codes), timber volume and distance from alpine meadows were identified at each sample point. Distance from Non-Forest Meadow (NFM) was used for the distance from alpine meadow data. Data intervals used and computer coding for each variable used are presented in Appendix II. Relative availability of the various habitat attributes within the study area was calculated from frequency distributions based on the 2548 sample points.

Habitat selection

Radio-tracking techniques for the present study have been described by Smith (1981). One hundred and eight re-locations of radioed goats were obtained within the area selected for intensive study between 1 November and 31 March during the winters of 1980-1981 (48 locations) and 1981-1982 (60 locations). With a substantially smaller sample size in the 1980-1981 preliminary analysis of habitat use (Fox and Raedeke 1982) identification of goat habitat was determined using approximate estimates of goat winter home range; subjective encirclings which included all winter re-locations for each individual goat as mapped by Smith (1981). All habitat sample points within the individual home ranges were then considered as used by goats. However, in the present analysis of data from both winters, identification of goat habitat is based solely on grid points which were identified as having goat radio relocations in the grid squares they represent. In addition, goat relocation grid points missed in the systematic sample of habitat characteristics were added to the sample so that a total of 2608 points were sampled with respecet to habitat characteristics. Eighty of these points had between 1 and 4 radio re-locations of goats (total 108 re-locations) and were weighted according to number of re-locations in all habitat use analyses. Frequency distribution using univariate habitat data from used versus available habitat was used to test (chi-square analysis) goat selection for various habitat characteristics. Frequency distributions were again used to test (chi-square analysis) for differences in goat use of selected habitat characteristics between the light snowfall winter of 1980-1981 and the heavy snowfall winter of 1981-1982.

Finally, using the interval scale variables, discriminant function analysis (Cooley and Lahnes 1971) was used to distinguish between goat habitat and non-goat habitat. A stepwise procedure was used, maximizing the minimum Mahalanobis distance (Nie et al. 1975). Accuracy of the discriminant function in predicting whether a point within the area of intensive study is within or outside goat winter habitat was also determined. Grid points which were predicted to be within areas used by goats in winter were also mapped to demonstrate the usefulness of this analysis in identifying goat habitat.

RESULTS

Ground Based Data

Snow conditions

The winter of 1980-1981 produced very little snow accumulation within the elevation range (0-3000 ft) present on the lower Cleveland Peninsula. Snow depths measured at 30 to 45 day intervals at elevations up to 2300 ft near the Bear Lake study site did not exceed 11 in. (Table 1). While the above measurements were made in relatively wind-free sites, an adjacent open ridgetop (2600') exposed to wind redistribution of snowfall developed a few snow-drifts from 3 to 4 ft deep from December through February. Although yearly winter snow depth measurements above sea-level are not available for the Ketchikan area, it is probable, judging from temperature records, that the winter of 1980-1981 was extreme in its lack of snow up to an elevation of 3000 ft. Such a minimal winter snow regime results in relative ease of travel for goats and the availability of forage which would normally be snow covered.

In contrast, the winter of 1981-1982 produced much greater snow accumulation with snow depth at 2300' reaching 84 in. Monthly comparisons between the two winters made at three elevations near the Bear Lake study site (Table 1) demonstrate the great differences in snow depth between these winters. The winter of 1981-1982 was likely well above average in terms of snow accumulation in the 0-3000 ft elevation range. The two winters thus provide an excellent opportunity to look for differences in goat habitat selection related to differences in winter snowpacks.

Table 1. Snow depth at three elevations during the winters of 1980-81 and 1981-82.

	Snow Depth (in)					
	500 ft		1150 ft		2300 ft	
Month	81*	82	81	82	81	82
November	—	0	–	0	–	6
December	2	8	5	–	10	49
January	0	24	3	27	6	49
February	1	43	5	48	11	65
March	0	43	0	56	0	84

* 81 = winter of 1980-1981
82 = winter of 1981-1982

Plant communities and forage biomass

Reconnaissance of the Cleveland Peninsula indicates the presence of an array of plant communities comparable to those present in the goat study area near Juneau (Appendix I; Fox and Taber 1981). However, several types are of very limited extent on the Cleveland Peninsula and some of the forest communities are enriched by the presence of several additional species, eg., *Chamaecyparis nootkatensis* and *Gaultheria shallon*. On the Cleveland Peninusla there are no permanent snowfields and several types of alpine--subalpine vegetation including Forb-*Cassiope*, *Empetrum* Sub-shrub and *Calamagrostis* Meadow are only minimally represented (see Appendix I for brief descriptions of the various plant communities present). Forest communities form by far the predominant vegetation on the peninsula and appear to encompass most of the goat wintering range.

The biomass measurements on the Cleveland Peninsula, broken down in Table 2, are reasonally comparable with those obtained in the Juneau study area (Table 3). The low total for the second subalpine forest stand on the Cleveland Peninsula can be explained by the prevalence of sapling conifers which provide relatively little foliage within goat foraging height while shading out shrubby understory below their canopies. Recognizing that only a few stands have been sampled in both study areas conclusions must be very cautious, but at present there is no evidence to preclude acceptance for the Cleveland Peninsula of plant community forage biomass figures derived in the Juneau study area.

Table 2. Results of biomass sampling by species for current annual growth (kg/ha) of winter forage in several forest community stands on the Cleveland Peninsula.

	Forest Community And Stand Location				
	Vaccinium Forest			Subalpine Forest	
Plant Species	900' E,30°	1000' E,35°	1300' E,30°	18-2300' S,30°	17-2100' S,25°
CONIFERS	*	(5p)**	*	(5p)	(5p)
Picea sitchensis		-		-	t
Tsuga spp.		11		26	65
SHRUBS	(9p)	(5p)	(8p)	(5p)	(5p)
Menziesia ferruginea	21	1	46	t	6
Vaccinium spp.	57	76	64	205	102
Total	78	77	110	205	108
FORBS	*	(20q)	*	(20q)	(22q)
Cornus canadensis		13		7	21
Coptis asplenifolia		t		5	t
Rubus pedatus		5		13	2
Tiarella spp.		-		4	t
Total		19		28	23

* not sampled

** (sample size); p=25cm X 10m plot, q=20cm X 50cm quadrat

t = trace = <.5 kg/ha

Table 3. Forage biomass (kg/ha) in forest community stands of the Juneau and Cleveland Peninsula study areas. Elevation, aspect and slope angle are given for each stand.

Forest Community And Location	Forage Type			Total
	Forbs	Shrubs	Conifers	
Vaccinium Forest				
Juneau; 1150',W,25°	38	60	19	117
Clev.Pen.; 900',E,30°	*	78	*	
Clev.Pen.; 1000',E,35°	19	77	11	107
Clev.Pen.; 1300',E,30°	*	110	*	
Subalpine Forest				
Juneau; 2200',NW,25°	20	199	30	249
Clev.Pen.; 18-2300',S,30°	28	205	26	259
Clev.Pen.; 17-2100',S,25°	23	108	65	196

* data not available

Winter food habits

Successful collections of recent goat fecal pellets were made during each of the eight winter visits to the Bear Lake study site. These samples are currently being analyzed for diet composition and the results will be presented on completion of these analyses as an addendum to this report.

During the winter visits to the Bear Lake study site evidence of feeding by goats was observed on the following species:

Cornus canadensis	*Rubus pedatus*
Vaccinium spp.	*Rubus spectabilis*
Polypodium sp.	*Lobaria* sp.
Chamaecyparis nootkatensis	Moss
Tsuga montana	

Habitat Mapping & Radio-Tracking Data

Habitat selection

Based on the area of intensive study on the lower Cleveland Peninsula the sites used by goats during winter indicate that significant selection by goats occurs relative to certain habitat characteristics. Elevation used by goats was not distributed according to its availability in the study area (chi-squared = 256, $p<.001$). Higher elevations were selected (Fig. 2) with median elevation being 1700 ft. for sites used by goats as compared to 770 ft. for the study area. Sites used by goats were

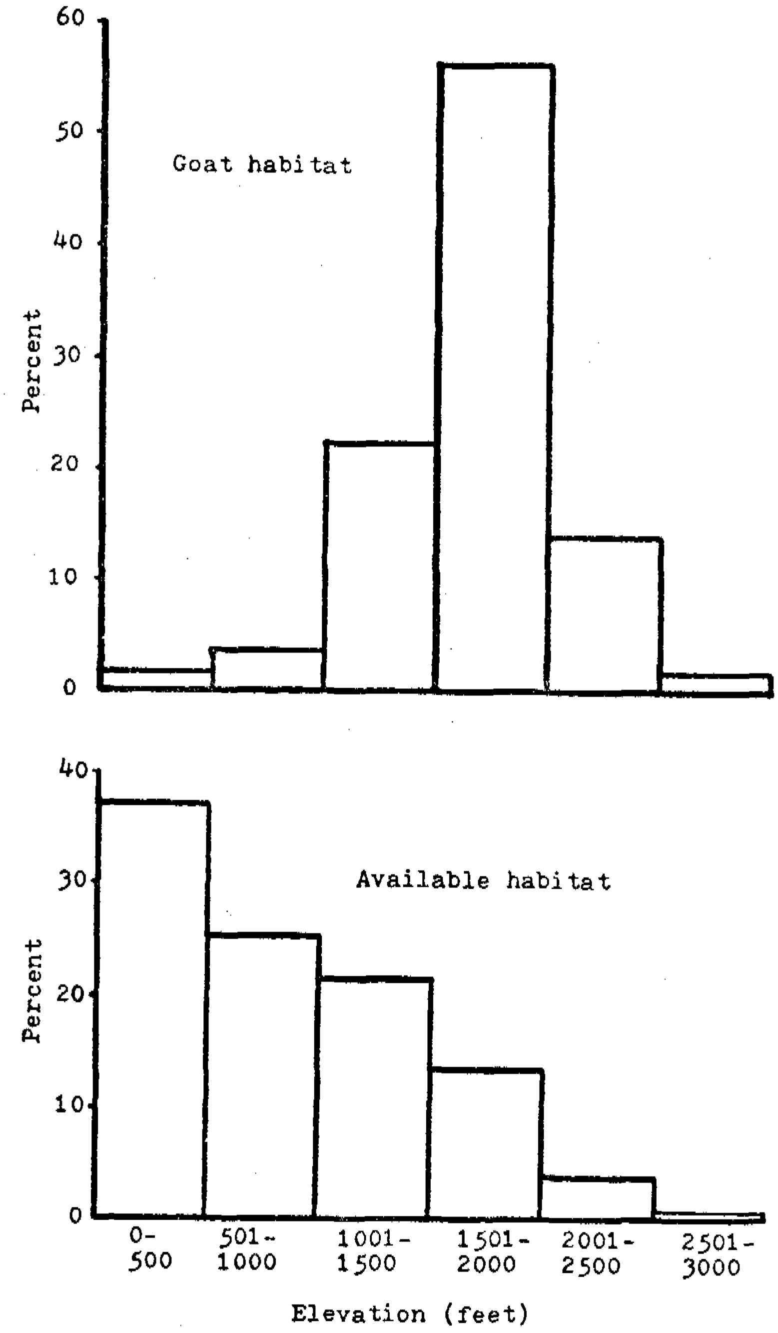

Figure 2. Distribution of elevation available on the Cleveland Peninsula study area as compared to that within goat habitat.

comprised of steeper slopes (median = 40°) than that available (median = 20°) in the study area (Fig. 3). Goat habitat was very different than available terrain with respect to distance from cliffs (chi-squared = 530, p<.001). Median distance from cliffs was about 1/8 mile at sites used by goats whereas it was about 1 mile in the study area, indicating strong selection for sites near cliffs (Fig. 4). The distribution of aspects used by goats was different from that available in the study area (chi-squared = 50, p<.001), and if aspects are arranged on a North to South continuum [(N)(NE,NW)(E,W)(SE,SW)(S)] then it becomes apparent that goats are selecting for more southerly aspects (chi-square = 33, p<.005) in winter (Figure 5). Goat habitat contained a different distribution of vegetation types than was available in the study area (chi-squared = 97, p<.001). The difference was accounted for by increases in High Elevation Forest and Slide Zone Forest and a decrease in Low Site and Muskeg Forest within goat habitat as compared to the whole study area (Fig. 6). Other vegetation types were used to a degree approximately proportional to their availability on the peninsula.

We have predicted certain changes in goat habitat selection related to differences in snow accumulation between winters. During the heavy snowfall winter of 1981-1982 we expected goats to use a) lower elevation, b) steeper slopes, c) more southerly aspects, d) less distance from cliffs and e) greater timber volume than in the light snowfall winter of 1980-1981. Results from the radio re-locations of goats show no statistically significant differences in use of these habitat characteristics between winters (Table 4). However, it is noteworthy that what differences in goat habitat use that do exist between winters all trend in the expected directions (Table 4).

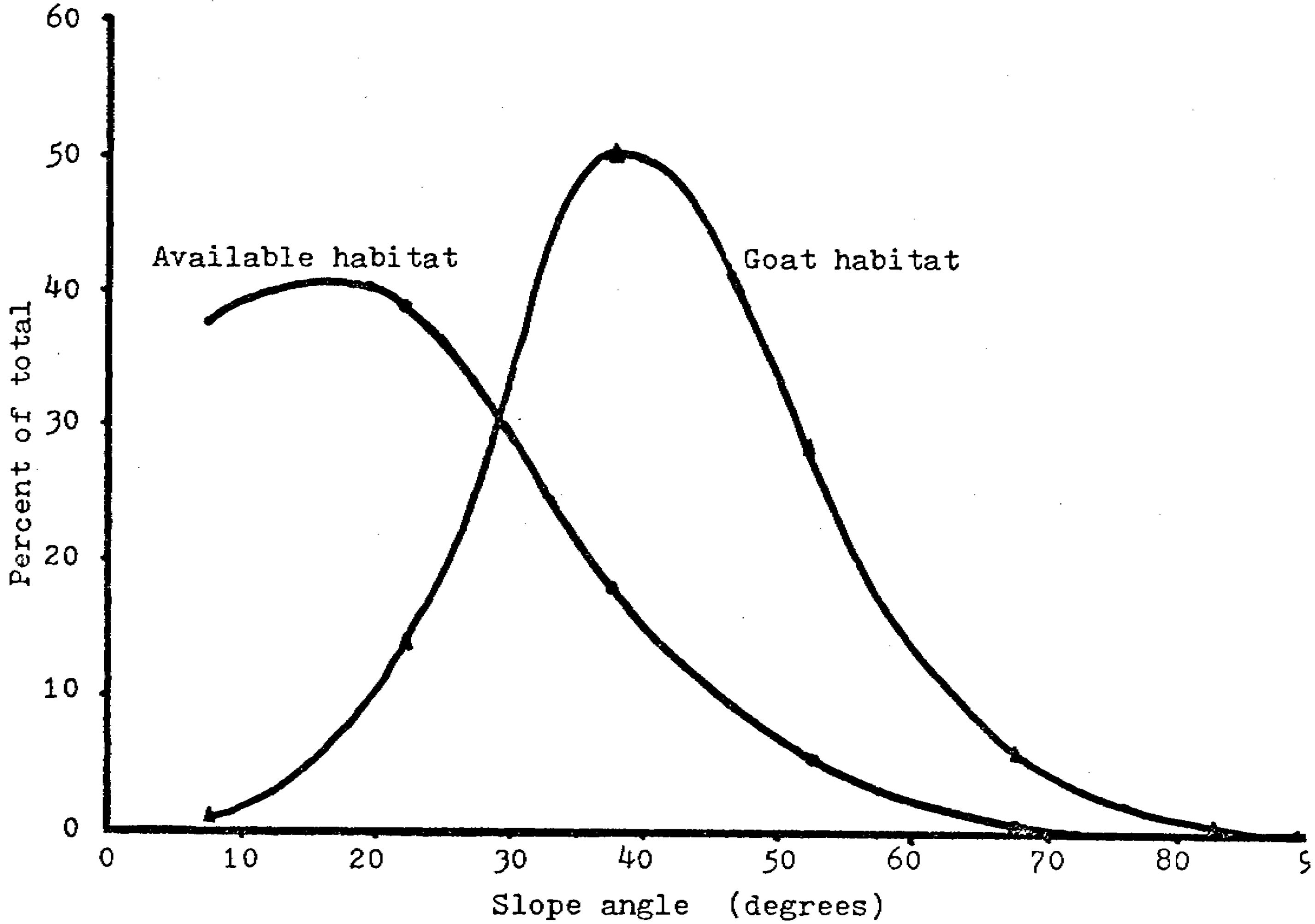

Figure 3. Distribution of slope angles available in the study area as compared to that within goat habitat.

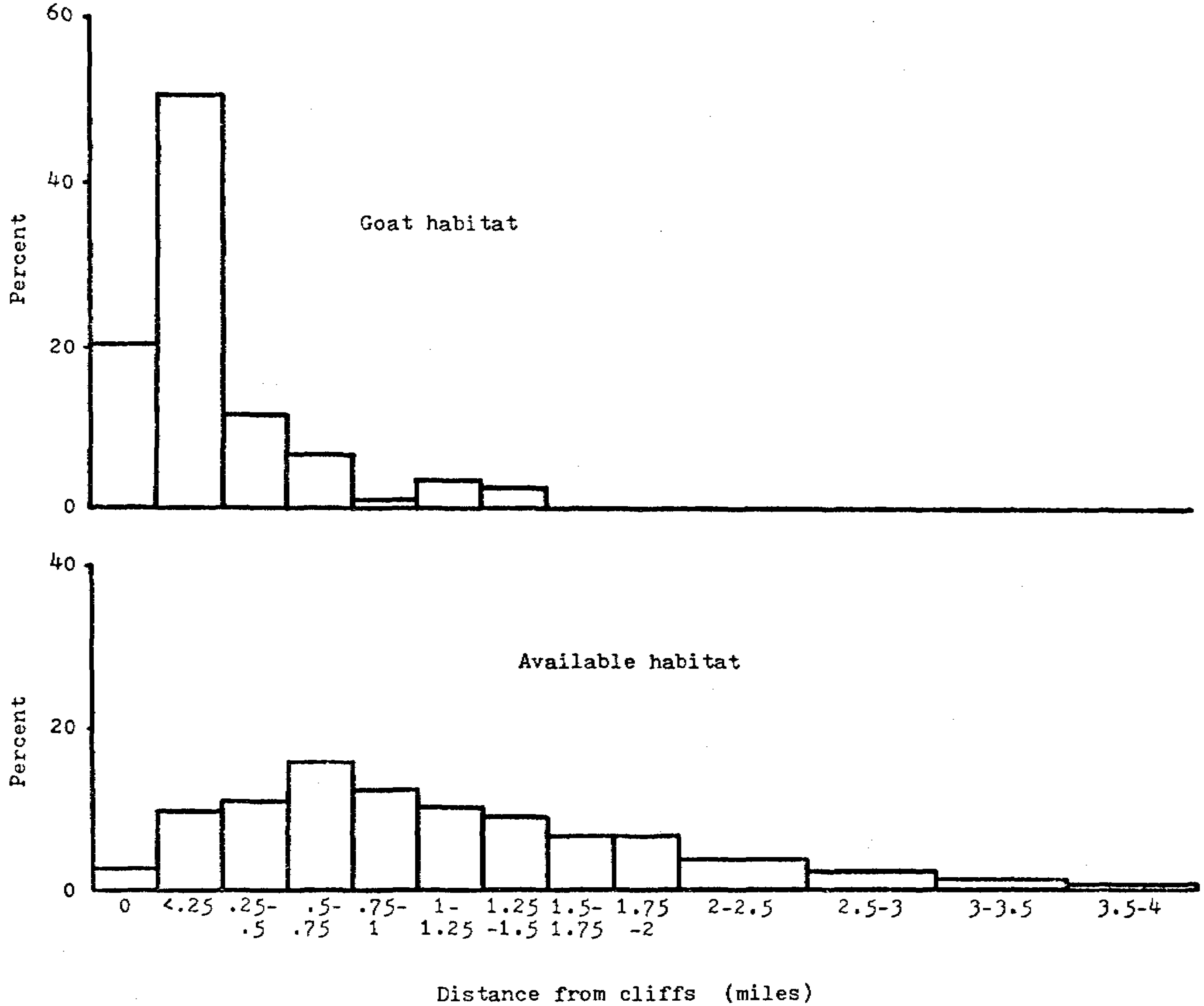

Figure 4. Distribution of habitat in terms of distance from cliffs for the available habitat as compared to that within goat habitat.

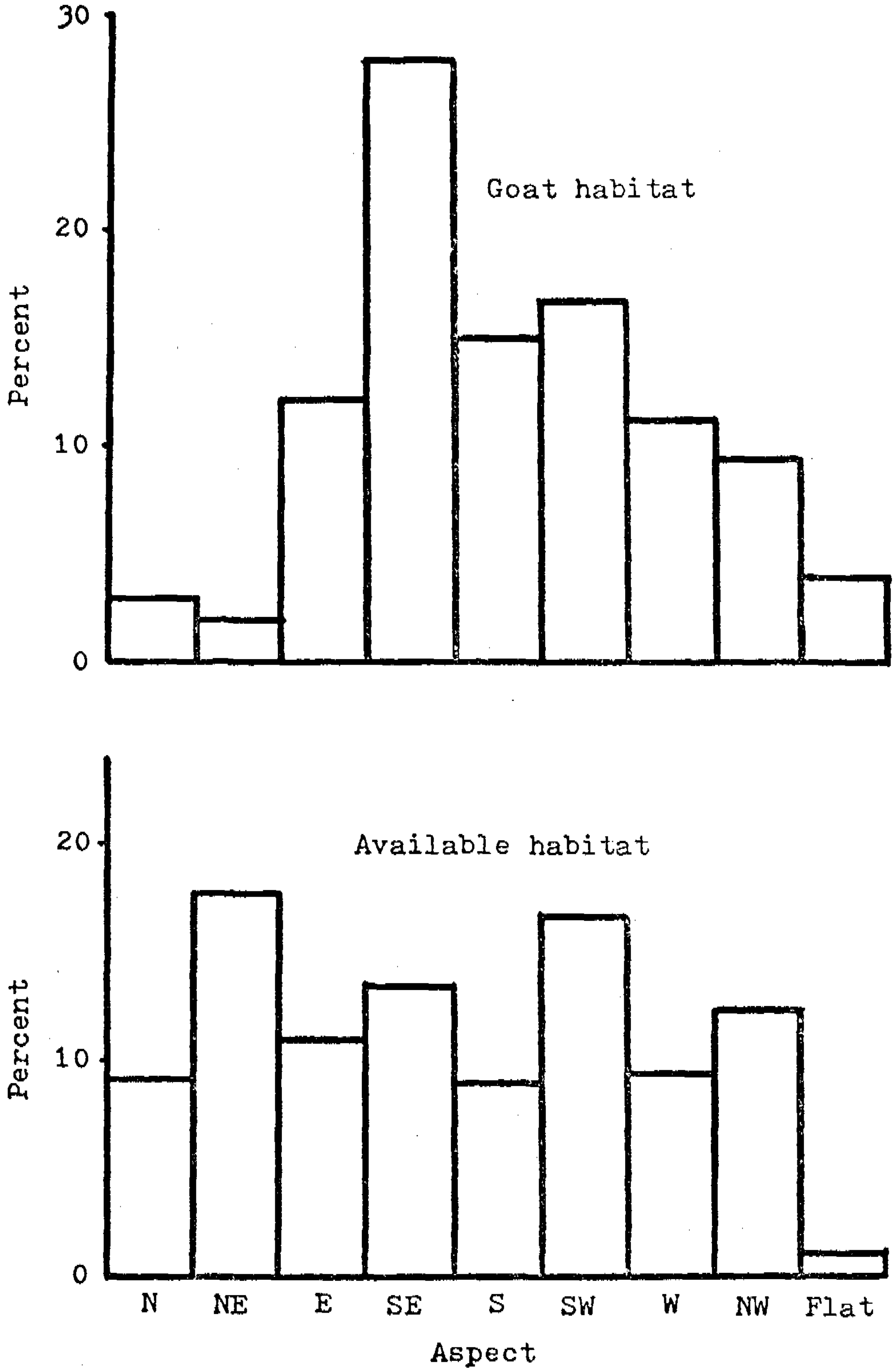

Figure 5. Distribution of available aspects as compared to that within goat habitat.

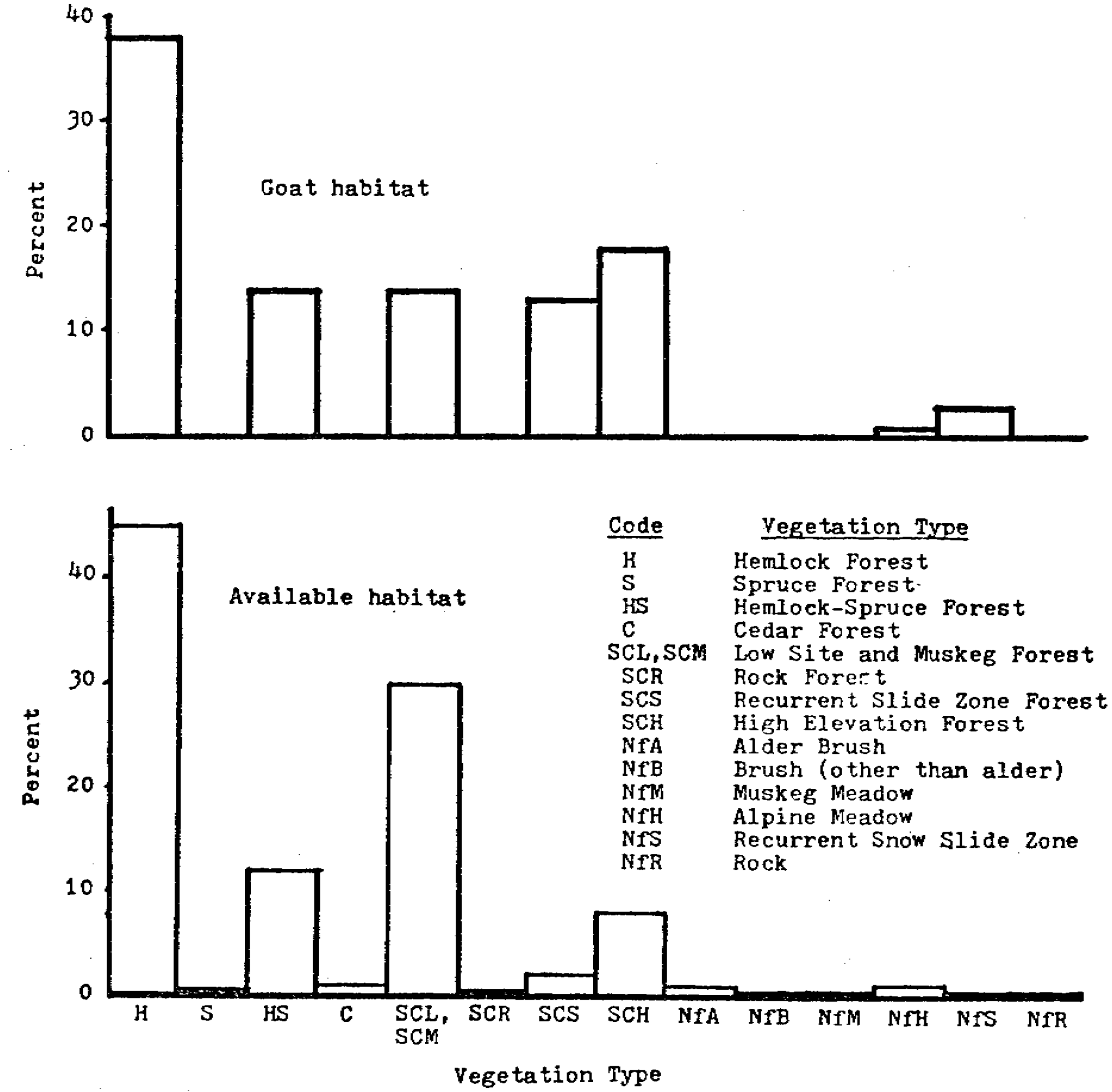

Figure 6. Relative presence of various vegetation types available as compared to that within goat habitat.

Table 4. Medians and chi-square tests for differences in goat use of selected habitat characteristics between the winters of 1980-81 and 1981-82.

Habitat variable	Median 1980-81	Median 1981-82	X^2	p
Elevation	1730ft	1680ft	4.90	<.25 (ns)
Slope	39°	43°	12.94	<.05 (ns)
Distance to cliffs	250m	175m	10.63	<.25 (ns)
Aspect*	3	4	7.65	<.25 (ns)
Timber volume**	7450	9800	4.83	<.25 (ns)

* North-South continuum (N=1)(NE,NW=2)(E,W=3)(SE,SW=4)(S=5)
** board-feet

For the discriminant analysis only variables which incorporate interval level measures are meaingful, thus precluding the use of vegetation type. In the present analysis the variables elevation, timber volume, slope, aspect (North-South continuum) and distance from cliffs are used to create a function which best separates goat habitat from non-goat habitat based on these habitat attributes. A simple correlation matrix of these variables is provided for reference (Table 5). Canonical coefficients of the variables with the discriminant function suggests the primacy of slope angle in determining sites used by goats (Table 5). Elevation and aspect also appear to be of some value in separating goat habitat from non-goat habitat. However, the high degree of intercorrelation among slope, elevation, and distance from cliffs (Table 4) indicates that the designation of a primary discriminating variable can be quite misleading. In general the discriminant function was useful in predicting whether a particular sample point was within or outside goat habitat. Eighty-one percent of the sample points were classified correctly to either goat habitat or non-goat habitat using this function (Table 6). Sample points predicted by the discriminant function to be within goat habitat were mapped. Outlines of clusters of these points were drawn by connecting boundary points which had no more than two non-goat habitat points separating them from the next adjacent goat habitat point (Fig. 7).

Table 5. Simple correlation matrix and cononical coefficients for habitat variables used in the discriminant function analysis.

Habitat Variable	Correlation Matrix: Elevation	Timber Volume	Slope	Aspect	Canonical Coefficients
Elevation					.31
Timber Volume	-.12				-.16
Slope	.50	.19			.70
Aspect	-.02	.02	.00		.28
Distance to Cliffs	-.50	-.06	-.44	.01	-.12

Table 6. Accuracy of the discriminant function in predicting the identity of sample map-grid points with respect to location within or outside goat habitat.

	Sample Grid Points		
		Predicted	
Identity	Actual	Correct	Incorrect
Goat Habitat	108	101	7
Non-Goat Habitat	2528	2038	490

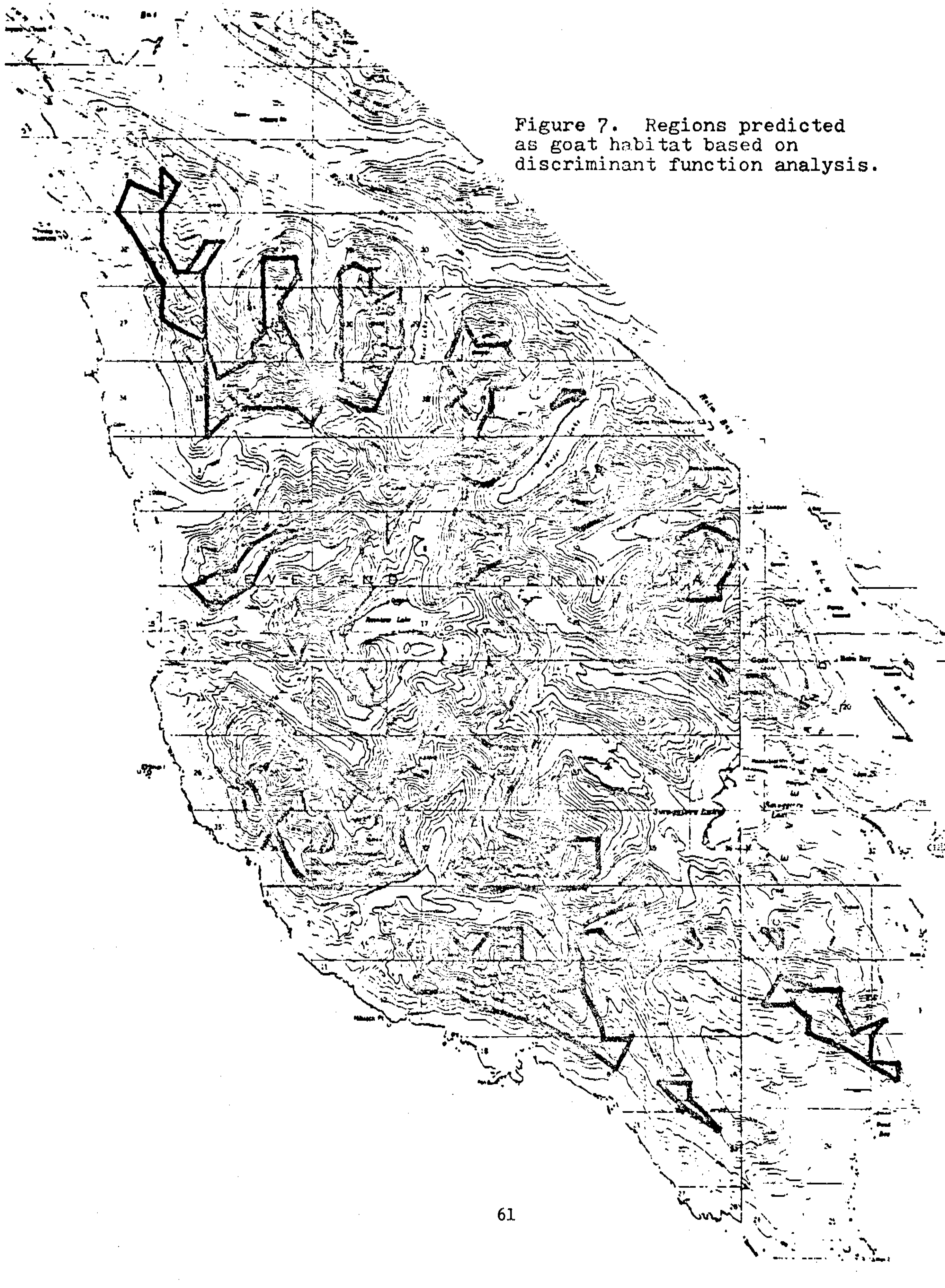

Figure 7. Regions predicted as goat habitat based on discriminant function analysis.

DISCUSSION

The results indicate that during winter, goats on the Cleveland Peninsula utilize predominantly forested sites on steep slopes at relatively high elevations, slightly more southerly aspects and in close proximity to cliffs. These findings, based on map-gridded radio relocations of goats and habitat characteristics derived from maps, corroborate fairly well those obtained by Smith (1981) using his visual observations of radioed-goat locations. With regard to findings from the Juneau studies (Fox and Taber 1981; Schoerr, Kirchoff, Wallmo, Fox and Taber 1982), the importance of steep slopes and sites in close proximity to cliffs is also demonstrated for the Cleveland Peninsula. Elevations and vegetation types used are somewhat different in the two study areas, due undoubtedly to the lack of windswept alpine sites on the Cleveland Peninsula.

On the Cleveland Peninsula, where virtually all potential wintering sites are in forested habitat, we previously suggested (Fox and Raedeke 1982) that the effects of snowpack accumulation should result primarily in goats descending to lower elevations as long as steep and broken escape terrain remains available nearby. Subalpine Forest plant community tends to provide greater potential forage biomass than lower elevation Vaccinium Forest (Table 3) so that under winter conditions with very little snowpack the higher elevation forests would have the most forage. The winter of 1980-1981 was one of very limited snow accumulation on the Cleveland Peninsula. The result was that, although subalpine meadows and heath mostly remained snowcovered, the higher elevation forests sustained little snow accumulation and provided substantial forage throughout the winter. During a winter such as 1981-1982 with much greater snow accumulation, and with normally increasing snowpack with elevation, we expected goats to move to lower elevations and use other habitat characteristics associated with diminished snow depth as described above. In the present study we did not find statistically significant shifts in goat habitat selection between the two winters of disparate snow accumulation even though the apparent trends in habitat selection were all in the expected directions. It is conceivable that with the inherent variability in goat selection of habitat a larger sample size might have produced significant results for some of the shifts in habitat use. It is also conceivable that the .01 sq mi resolution of our data set masked actual shifts in goat habitat selection on a smaller scale. However, the salient point is that within the constraints of the radio-tracking and mapping techniques used our deliniation and description of goat winter habitat on the Cleveland Peninsula does not appear to be greatly affected by differences in winter severity. Thus the characteristics of winter habitats used by goats on the lower Cleveland Peninsula would appear to remain fairly constant from year to year and our description of goat winter habitat may be viewed with some confidence in assessing overlap or conflict with human use of habitat on the peninsula.

The relative importance of the various habitat characteristics used in discriminating goat from non-goat habitat has been alluded to above with the caution that intercorrelation among variables can make such ranking quite misleading. In the present stepwise discriminant analysis slope angle was selected first as the variable which by itself best brought about separation of goat habitat from non-goat habitat. But, in the preliminary analysis for this study (Fox and Raedeke 1982) distance from cliffs was selected as initially the best discriminating variables. And in the Juneau studies, distance from cliffs was suggested by Fox and Taber (1982) as of primary importance in determining goat habitat and was selected as the best initial variable in a discriminant function analysis similar to that used here (Schoen, Kirchoff, Wallmo, Fox and Taber 1982).

From further analysis of the results of the present study it becomes apparent that three habitat characteristics, slope angle, distance from cliffs and elevation from the last and relatively equivalent discriminators of goat habitat. The ascendency of each variable appears related to both the characteristics of the study area and the type of results presented. In the discriminant analysis procedure used in this study we have been burdened with two important drawbacks; 1) since we do not have all the goats on our intensive study area marked we have undoubtedly misidentified some data points as non-goat habitat when in fact they are used by goats, and 2) the number of non-goat habitat data points is much greater than that for goat habitat, thus weighting the accurracy of our procedure in favor of predicting where goats are not. These problems can cause some discrepancies in the results of prediction accuracy. For example, in basing a discriminant function on each of the three variables of concern separately we find that the predicted identies of all sample grid points (goat or non-goat habitat) was 83 percent correct on the basis of elevation alone, 77 percent on the basis of slope angle alone and 64 percent on the basis of distance from cliffs alone. On the other hand, 72 percent of the known goat locations were identified correctly based on a discriminant function using elevation alone, 85 percent using slope angle alone, and 93 percent using distance from cliffs alone (Table 7). In order to lessen the importance of the weighting drawback described above we can assess the value of these three variables when prediction accuracy for both goat and non-goat habitat are weighted equally in determining overall accuracy. Under this condition, discriminant function identity (goat or non-goat habitat) predictions are 78 percent accurate based on elevation alone, 78 percent accurate based on distance from cliffs alone, and 81 percent accurate based on slope angle alone (Table 7). Each of these three habitat characteristics appears to be of comparable importance in distinguishing goat habitat and since they are intercorrelated the stepwise inclusion of one in a discriminant function necessarily lowers the added value of the other two. Since 50 percent accuracy is equivalent to the result of random selection, timber volume and aspect are apparently poor single predictors of goat habitat (Table 7), but provide some additional information when included with the other variables.

The primacy of one of the three important habitat characteristics in discrimination of goat habitat is probably also related to characteristics of the study area. In a setting such as the Cleveland Peninsula where islands of steep terrain are surrounded by relatively level valleys slope angle alone may be enough to form a substantial discrimination between goat and non-goat habitat on the scale of our radio-tracking data. Where slope angle is more consistently steep (as in the Juneau study areas) distance from cliffs may assume an increasingly important role in delineating goat habitat. Undoubtedly distance from cliffs is important in both cases but in the latter it becomes more manifest due to the lesser differentiation of slope angles present.

Table 7. Accuracy of discriminant functions based on single habitat variables in correctly predicting the actual identities (goat or non-goat habitat) of sample data points used in the analysis.

	Percent accuracy		
Habitat variable	Overall[1]	Known goat location[2]	Overall with equal weight[3]
Distance to cliffs	64	93	78
Elevation	83	72	78
Slope	77	85	81
Aspect	61	59	61
Timber volume	56	48	52

1) all sample data points

2) goat habitat data points only

3) all sample data points, but with equal weight given to the goat and non-goat subgroups

Any attempt to extrapolate the predictive capabilities of the present discriminant function to other areas may confront problems if the variables occur in different ranges of values than those encountered here. Elevation is likely to be a problem in this regard since goats are known to live in areas with widely different elevation ranges (often due to latitude differences). However, having acknowledged that elevation is well correlated with both slope angle and distance from cliffs in the present study, a re-analysis of the data using the same discriminant function procedure, but with elevation removed, shows only a 2 percent loss in habitat prediction accuracy from that of the original five variable function. This is encouraging in considering the potential of a discriminant function using distance from cliffs, slope angle, aspect and possibly timber volume for predicting goat habitat in new areas.

The predictive capability of our discriminant function model allows mapping of goat habitat and provides a useful visualization of potential goat winter habitat on the lower Cleveland Peninsula (Fig. 7). Conclusions of the Juneau study (Fox and Taber 1981) also provide a means for mapping potential goat wintering sites (areas within 500m of steep and broken "escape" terrain) and allow a comparison with the discriminant function prediction (Fig. 8). Results of the present study show that 79 percent of goat re-locations were within 500 m of cliffs, with 90 percent being within about 1 km. The map based on the discriminant function analysis (Fig. 7) is somewhat more restrictive than that based on distance from cliffs and suffers from the fact that the gridding procedure with .01 sq mi resolution necessarily omits some goat habitat on the periphery of the outlines. Still, the comparable result of these two approaches is

Figure 8. Regions predicted as important goat winter habitat based on distance (500m) from escape terrain.

encouraging and strengthens our assessment of goat winter habitat selection on the Cleveland Peninsula.

The descriptions and predicted areas of goat winter habitat in the present study should provide managers a basis for including consideration of mountain goat habitat needs within the planning process for human exploitation on the Cleveland Peninsula. Extrapolation to other areas of discriminant functions predicting goat habitat which are based on Cleveland Peninsula data need to be tested but, judging at least from the usefulness here of conclusions based on studies in the Juneau area, the prospects appear to be promising.

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APPENDIX I

Plant Communities Occurring in the Juneau and Cleveland Peninsula Study Areas

Forb-*Cassiope*: A forb-subshrub vegetation characterized by *Cassiope mertensiana*, *C. stelleriana*, *Phyllodoce aleutico* and an admixture of numerous glaminoids and forbs, including several species of *Saxifraga*. It occurs from timberline to near the upper limits of vegetation and is typical of well drained rock outcrops and relatively stable scree slopes.

Empetrum Subshrub: Characterisitc species include *Empetrum nigrum*, *Loiseleuria procumbens* and *vaccinium uliginosum*. This vegetationis typical of dry fellfield conditions on alpine ridgetops and other exposed sites.

Cassiope Heath: A subshrub vegetation characterized by dense mats of *Cassiope mertensiana*, *C. stelleriana*, *Phyllodoca aleutica* and *Luetkea pectinata*. It occurs above and below timberline under moderately moist conditions, often in slight depressions and more typically on northerly aspects.

Calamagrostis Meadow: A sedge-forb meadow vegetation usually dominated by *Carex macrochaeta* but characterized by the presence of *Calamagrostis canadensis*. It occurs on well drained, moderately exposed slopes near timberline.

Veratrum Meadow: Lush sedge-forb meadow vegetation characterized by *Corex macrochaeta*, *Veratrum viride*, *Heracleum lanatum* and numerous other forbs. It occurs on relatively well drained but moist subalpine slopes and is most common on southerly aspects.

Fauria Meadow: A sedge-forb meadow vegetation dominated by *Fauria crista-galli*. It occurs typically below timberline in slight depressions, under moist conditions and is more common on northerly aspects.

Carex Muskeg: A wet sedge meadow vegetation characterized by *Corex nigricans*, other *Carex* spp. and *Andromeda polifolia*. It occurs on poorly drained level sites or gentle slopes below timberline to sealand.

Krummholz: Stunted and wind-flagged *Tsuga mertensiana* and *Picea sitchensis* trees occurring at the upper limits of timberline.

Alnus Shrubland: A tall shrubland vegetation dominated by *Alnus sinuata* with predominantly herbaceous understory, typically including the fern, *Athyrium filix-femina*. It occurs commonly in avalanch accumulation zones and on recently glaciated terrain at or below timberline.

Subalpine Forest: A usually open coniferous forest of *Tsuga mertensiana* and *Picea sitchensis* characterized by a dense shrub understory dominated by *Vaccinium* spp. It occurs on relatively well drained sites.

Oplopanax Forest: Open or closed Tsuga spp. and Picea sitchensis forest vegetation with the understory dominated by Oplopanax horridus. It occurs on moist but moderately drained sites.

Vaccinium Forest: Closed forest dominated by Tsuga heterophylla and Picea sitchensis and a shrub understory of Vaccinium spp. and Menziesia ferruginea. It occurs on relatively well drained sites and is the most common forest type.

Vaccinium Forest Outcrop: This is a special case of Vaccinium Forest (described above) which was characterized by an extremely sparse understory. It was characteristic of steep and broken, but fully forested, terrain (rock outcrops) which was also extensively used by goats.

APPENDIX II

Cleveland Goat Study

DATA CODES

Aspect

1=Flat
2=N
3=NE
4=E
5=SE
6=S
7=SW
8=W
9=NW

Slope (degrees)

1=0-15
2=16-20
3=21-25
4=26-30
5=31-37
6=38-50
7=51-65
8=66-90

Elevation

100ft intervals

Timber Volume (board-feet/acre)

0=0
1=1-8,000
2=8-20,000
3=20-30,000
4=30-50,000
5= 50,000

Distance From Cliffs And Alpine Meadows (miles)

0=0
1= .25
2=.25-.5
3=.5-.75
4=.75-1
5=1-1.25
6=1.25-1.5
7=1.5-1.75
8=1.75-2
9=2-2.5
10=2.5-3
11=3-3.5
12=3.5-4
13=4-5
14=5-6
15=6-8
16= 8

Vegetation Type (USFS code)

1	=	(H)	Hemlock Forest
2	=	(S)	Spruce Forest
3	=	(HS)	Hemlock-Spruce Forest
4	=	(C)	Cedar Forest
5	=	(SCL,SCM)	Low Site and Muskeg Forest
6	=	(SCR)	Rock Forest
7	=	(SCS)	Recurrent Slide Zone Forest
8	=	(SCH)	High Elevation Forest
9	=	(NfA)	Alder Brush
10	=	(NfB)	Brush (other than alder)
11	=	(NfM)	Muskeg Meadow
12	=	(NfH)	Alpine Meadow
13	=	(NfS)	Recurrent Snow Slide Zone
14	=	(NfR)	Rock

APPENDIX B.

GROUP SIZE AND MOVEMENTS OF A DISPERSED, LOW DENSITY GOAT POPULATION WITH COMMENTS ON INBREEDING AND HUMAN IMPACTS

C. A. Smith and K. J. Raedeke

PRESENTED TO:

THE NORTHERN WILD SHEEP AND GOAT COUNCIL
FT. COLLINS, COLORADO
MARCH 17, 1982

GROUP SIZE AND MOVEMENTS OF A DISPERSED, LOW DENSITY GOAT POPULATION WITH COMMENTS ON INBREEDING AND HUMAN IMPACTS

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ABSTRACT

The population of mountain goats (Oreamnos americanus) on the Cleveland Peninsula in south coastal Alaska consists of some 50 to 70 animals living in groups with a mean size of 6.4 goats. Sub-populations occupy relatively small patches of habitat consisting of slides, rock outcrops or forested areas exceeding 40 degrees mean slope on discrete ridge complexes separated by forested valleys ranging from .8 to 2.4 km wide.

Radio-telemetry studies revealed that females were sedentary and exploited small home ranges. Conversely, most males made extensive movements associated with the rut, crossed low elevation valleys, and interacted with several groups.

The small size and patchy distribution of groups creates high potential for inbreeding or periodic local extinction. Exchange of genetic material between groups and optimum productivity occur only because of the inter-ridge movements of males during the rut. Despite the atypical nature of the goat habitat in this area, no unnatural barriers to such movement currently exist.

Within the next 5 years, timber harvest activity will begin on the Cleveland Peninsula. Due to the distribution of commercial timber, virtually every valley eventually will be roaded and/or logged. Habitat alteration, human activity and illegal hunting are expected to reduce inter-ridge movement by males and increase mortality. This could lead to reproductive isolation and instability of groups. The combined effects of genetic isolation and human harassment/mortality may lead to exterpation of many, if not all, sub-populations in the area.

INTRODUCTION

With the settlement of native land claims in 1971[1] and the national interest lands issue in 1980[2], many legal obstacles delaying resource development in Alaska have been removed. In the southeast Panhandle, these acts have resulted in accelerated mineral and timber extraction on lands not designated as wilderness. Accordingly, wildlife biologists are under increasing pressure to gather data necessary to minimize and mitigate habitat losses resulting from human activities.

In anticipation of impending logging activity on the lower Cleveland Peninsula, the Alaska Department of Fish and Game, the U.S.D.A.Forest Service and the University of Washington have undertaken a 3 year cooperative study of mountain goat (Oreamnos americanus) ecology and habitat use in this area. The primary objectives of this work are to determine distribution and abundance of goats, identify their movement patterns and critical habitats and to evaluate their food habits. The information gathered is to be used in timber sale and road layout planning to minimize impact of timber harvest activities on goats.

Fox and Raedeke (1982) have analyzed the distribution of vegetation and terrain types on a portion of the area and using telemetry data reported by Smith (1982) have made preliminary estimates of important goat habitat. This work revealed that distance to cliffs (i.e. broken terrain with slopes greater than 50°) was the most important factor in determining goat use of the area. Fox (1981) and Schoen et. al. (1982) identified the same relationship in the Juneau vicinity and determined that goats make little use of forested areas over 500 m from cliffs.

The distribution of goats on the lower Cleveland Peninsula is closely tied to specific, isolated patches of escape terrain within the forest. This has significant consequences with respect to breeding in this population. The purpose of this report is to evaluate distribution and movements of goats in this area with reference to reproductive biology.

P. Harrington (USFS) and R. Wood (ADF&G) were instrumental in organizing agency funding of this study and collected some of the initial data. H. Hase, B. Marr and M. Tehan assisted in the 1980 field surveys and J. Schoen, S. Brainerd and L. Smith assisted with the capture of goats.

STUDY AREA

The lower Cleveland Peninsula (Figure 1) is located approximately 40 km northwest of Ketchikan, Alaska within the Tongass National Foerest. The climate is influenced by maritime weather which produces relatively cool summers and mild winters for this latitude, as well as an average of 380 cm of precipitation per year. Although warm temperatures occasionally eliminate snow cover below 100 m elevation during winter, snowpack above 600 m often exceeds 2 m from December to March.

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1. Alaska Native Claims Settlement Act of 1971. United States Congress
2. Alaska National Interest Lands Conservation Act of 1980. United States Congress.

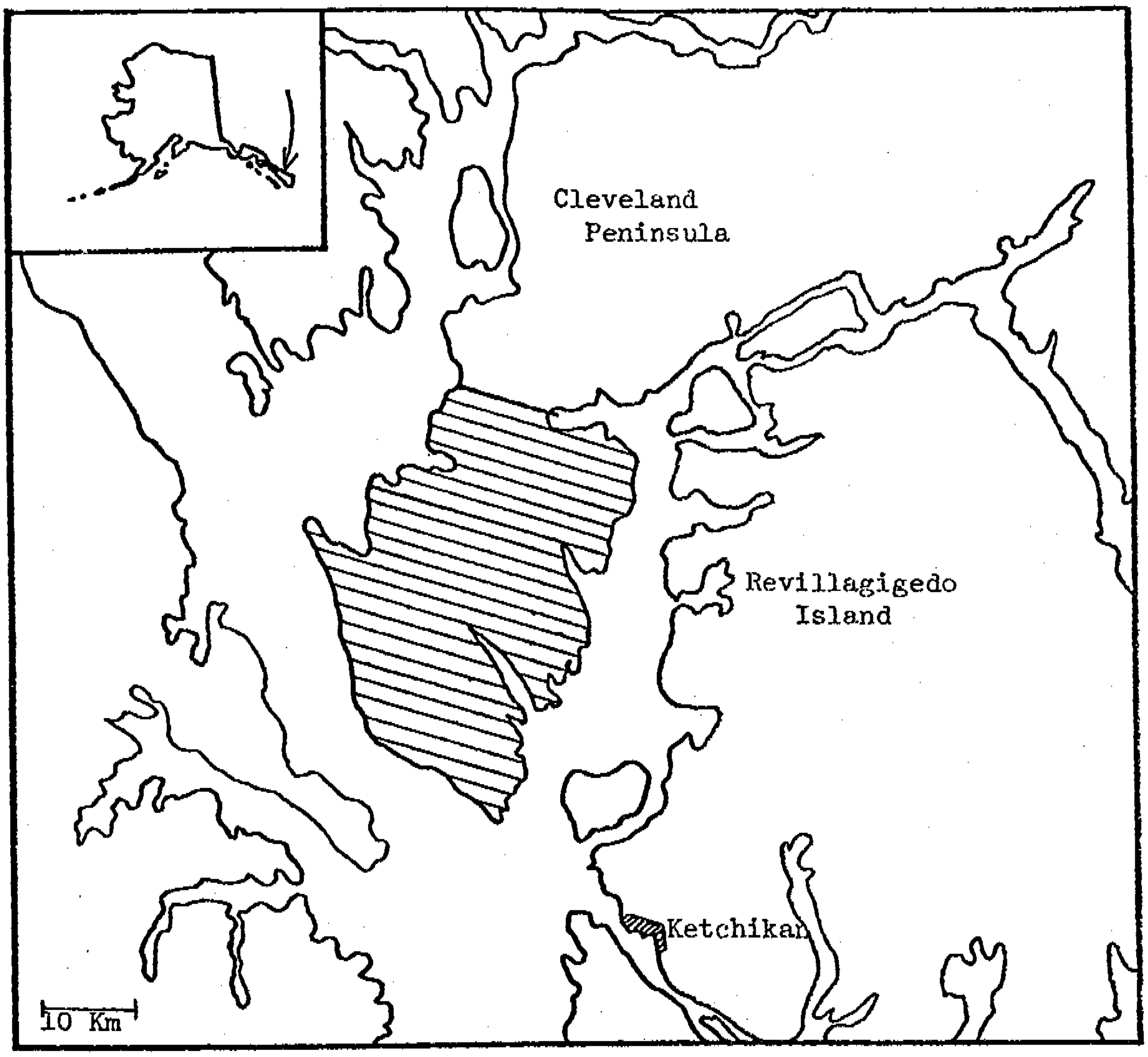

Figure 1. Location of the lower Cleveland Peninsula study area (shaded portion) in southeastern Alaska.

The topography is characterized by rolling ridges with scattered steep slopes and elevations ranging to 960 m. The predominant vegetation is western hemlock - Sitka spruce (Tsuga heterophylla - Picea sitchensis) forest (Harris and Farr, 1974), which completely covers most ridges. Breaks in the forest cover are provided by rock outcrops, slide zones, poorly drained muskegs and limited alpine meadows near some ridge tops. Fox and Raedeke (1982) provide a quantitative analysis of vegetation types.

METHODS

Distribution, size and composition of groups were determined by on-ground observations and aerial surveys during summer 1980 and through observations incidental to telemetry flights from 1980 to 1982. Data presented represent maximum number of goats observed at one time on each ridge complex over the course of the study, exclusive of known mortality, emigration or duplications of radio collared males. Local residents were also interviewed regarding historic goat numbers and distribution.

Goats were captured using standard helicopter darting techniques (Schoen et. al. 1982) with "Cap-Chur" (Palmer Chem. Co., Douglasville, Ga.) equipment and M99, etorphine, (D-M Pharmaceuticals, Rockville, Md.) between 9 and 24 August 1980 and 28 July and 13 September 1981. Captured animals were sexed, aged, measured and fitted with radio-transmitter collars (Telonics, Mesa, Arizona) in the 150.000 - 151.000 MHZ. range.

Telemetry flights were made in a PA-18-150 Super-cub equipped with dual, twin element yagi antennae. Regular tracking began in November 1980 and is continuing as of this writing. Flights were made once weekly or as often as weather permitted. Relocations were recorded using an x-y coordinate grid system with grid interval equal to .16 km (.1 mile).

The rutting season in goats is generally believed to occur between late October and early December, with a peak in late November (Brandborg 1955, Geist 1964, Chadwick 1973). For purposes of this report, movements made between 20 October and 15 December were considered to be associated with the rut.

RESULTS

GROUP SIZE AND DISTRIBUTION

The lower Cleveland Peninsula supports 8 groups of goats, having a mean size of 6.4 (Table 1). Figure 2 illustrates their midsummer distribution. One additional ridge, Gold Mountain, was said to have supported goats in the past, but since the mid 1950's, the only sighting reported to us was of a lone goat in July 1981 (H. Ludwigsen, pers. comm.).

Kids comprised 19.4 percent of the population in the 1980 sample (n=31) and 15.0 percent in 1981 (n=20). These figures are slightly lower than those determined for other populations in the Ketchikan vicinity which averaged 25.8 percent kids in 1980 and 24.9 percent in 1981 (ADF&G unpubl. data).

Table 1. Minimum group sizes and compositions on the lower Cleveland Peninsula, summer 1980 and 1981.

Ridge Complex	Adult Male	Adult Female	Adult Unknown	Kids	Total	Year
Port Stewart Ridge	1	2	1	1	5	1981
Mt. Burnett/South Ridge	3	1	3	1	8	1980
Helm Bay North Ridge	2	-	-	-	2	1981
Bear Lake West Ridge	4	6	2	5	17	1980
Bugge Ridge	3	-	3	-	6	1980
Niblack Peak	1	-	4	-	5	1981
Bald Ridge	-	3	1	2	6	1981
Caamano Ridge	2	-	-	-	2	1981
Total	16	12	14	9	51	
$\bar{x}$	2.00	1.50	1.75	1.13	6.38	

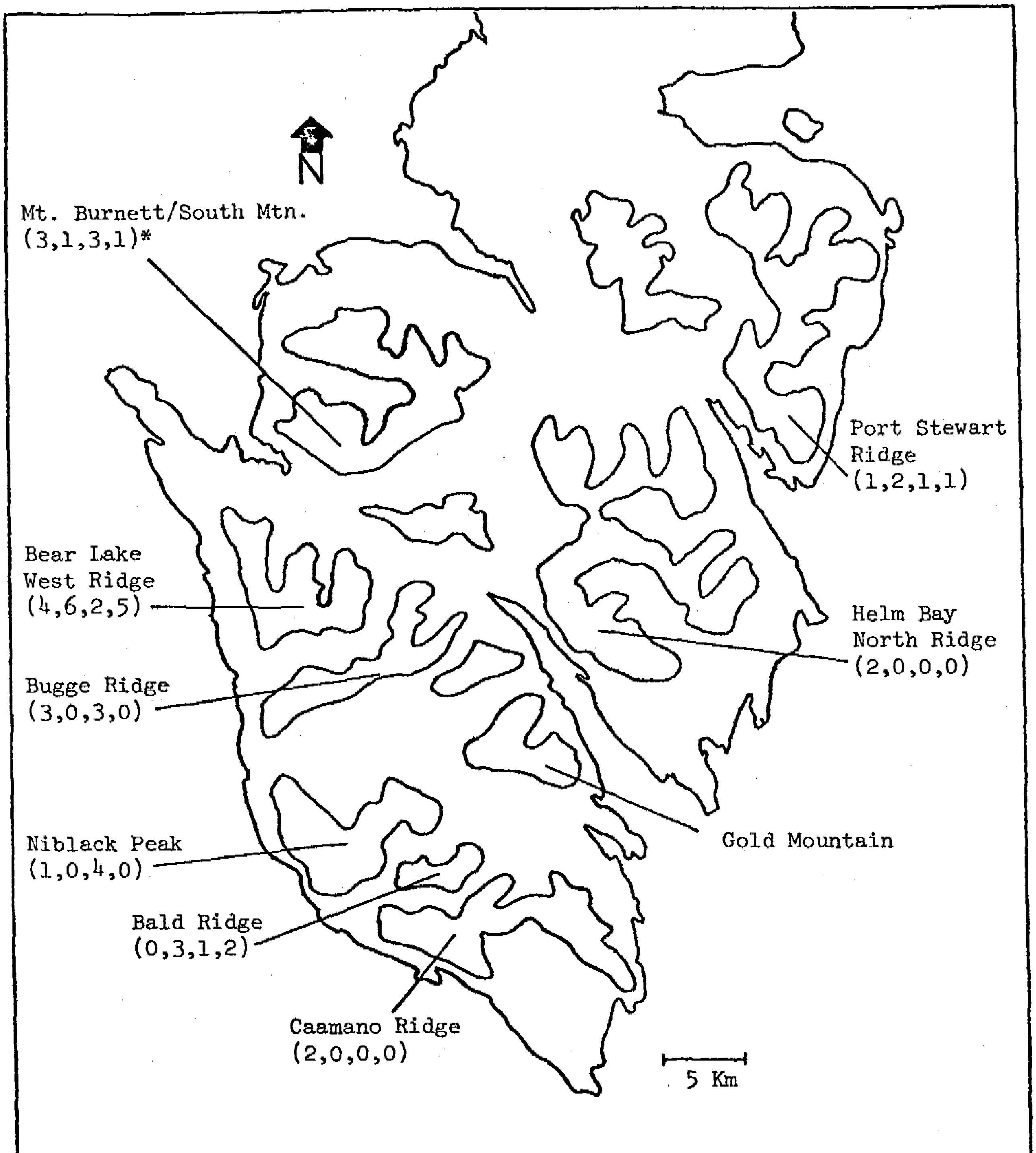

Figure 2. Midsummer distribution, minimum size and composition of mountain goat subpopulations on the lower Cleveland Peninsula. Ridge complexes differentiated by the 330 m contour. *(Males, Females, Sex/Age unknown, Kids).

INDIVIDUAL MOVEMENTS

Eleven goats (7 females, 4 males) were captured and radio collared in 1980 and 1981. During the breeding season in 1980, the movements of 6 females and 3 males were documented. In 1981, 4 females and 3 males were followed during the rut.

Convex annual home range polygons of the radio collared female goats are illustrated in Figure 3. With the exception of the emigration of #9, no female left the ridge complex on which she was marked. Conversely, 3 of the 4 males were found to make repeated movements across low elevation timbered valleys during the November-December rut (Figure 4). At other times, males used small seasonal ranges on single ridges (Smith 1982). The only male which did not move between ridges during the rut may have been suffering from physical disability. He died at age 10 apparently of malnutrition the following February in spite of the fact that the winter of 1980-81 was extremely mild.

DISCUSSION

The size and distribution of these goat sub-populations have particular consequences for their stability and breeding biology. Although estimated minimum group sizes may be conservative, it is evident that some of these sub-populations are at the lower end of the range of viable group sizes. Loss of only 2 members could represent 25-100 percent mortality in all but the Bear Lake Ridge group. Furthermore, some groups may lack sufficient adults of both sexes to be reproductively self sufficient at this time. Inter-ridge movements by males during the rut are important in optimizing productivity in existing groups. Without such movement, females may pass the rut without being bred as noted for isolated females in Idaho (Brandborg 1955, p. 92).

Although dispersal of females could eventually result in establishment of viable sub-populations on ridge complexes which are currently vacant or occupied soley by males, female goats are generally traditional in range use and do not often explore new areas (Brandborg 1955, Chadwick 1973, Smith 1976, Kuck 1977, Rideout 1977, Schoen, et.al. 1982). The 1 subadult female which did disperse during this study, moved 75 km to the higher ridges on the upper Cleveland Peninsula rather than to another patch of habitat on the lower peninsula. The lack of observations of goats on Gold Mountain for over 20 years may indicate that once vacated, ridges on the lower Cleveland Peninsula will be recolonized very slowly.

Several authors have commented on the tendency of male goats to move between ridges occupied by females during the rut (Geist 1964; Chadwick 1973, p. 54; Smith 1976, p. 167). Geist (1971, p. 90) and Rideout (1977) have suggested there are outbreeding benefits of this behavior to sheep and goat populations which frequently disperse into scattered groups of closely related females with which males associate primarily during the rut. Goats on the lower Cleveland Peninsula generally follow this pattern. Nevertheless, inbreeding cannot be discounted in this population.

Assume for example, that the reproductive portion of this population (i.e. goats over 2 years of age) consists of 12 males and 20 females which freely, and randomly interbreed. Such a population would have an effective population

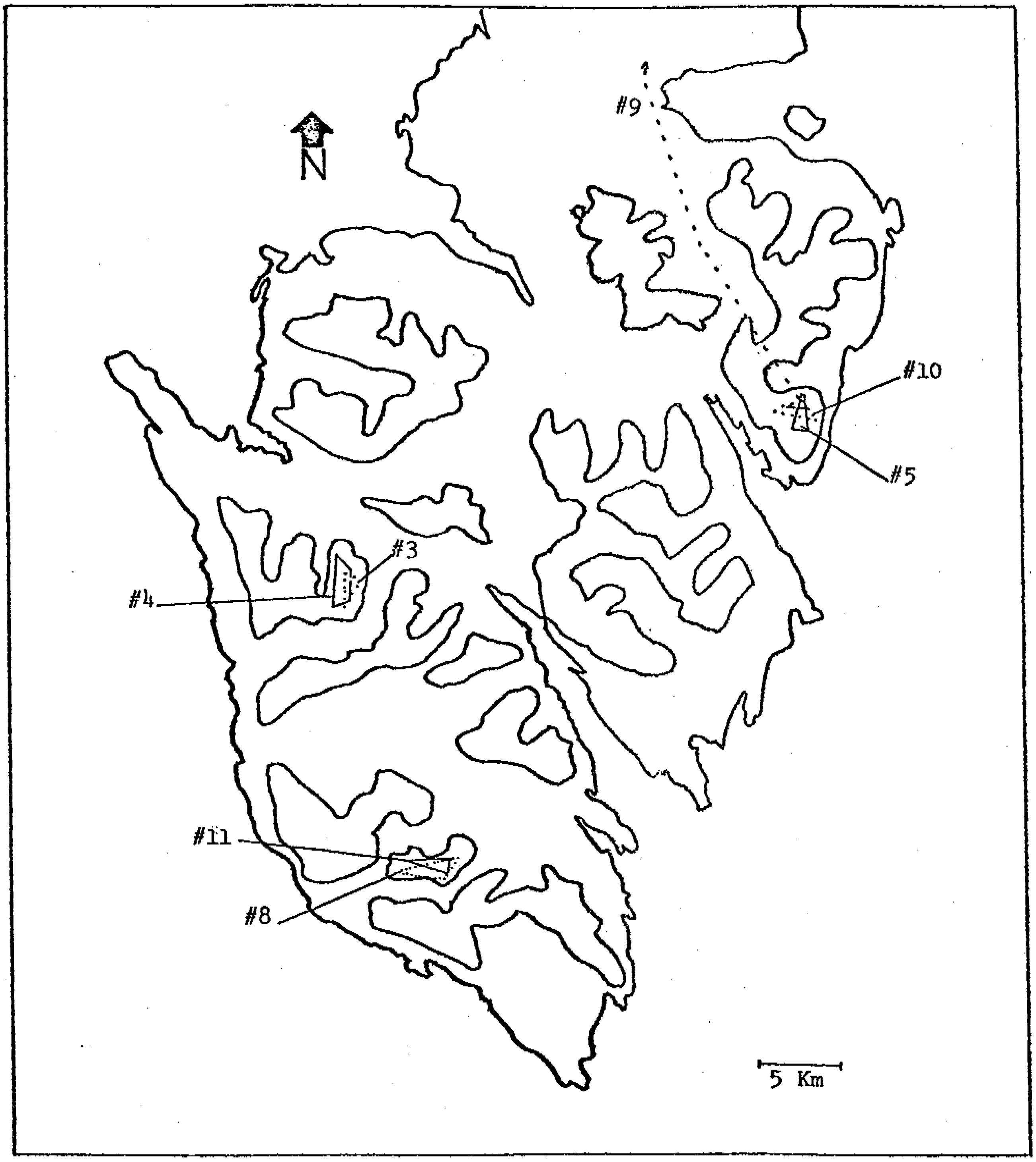

Figure 3. Home range polygons of radio-collared female mountain goats on the lower Cleveland Peninsula, August, 1980 - February 1982.

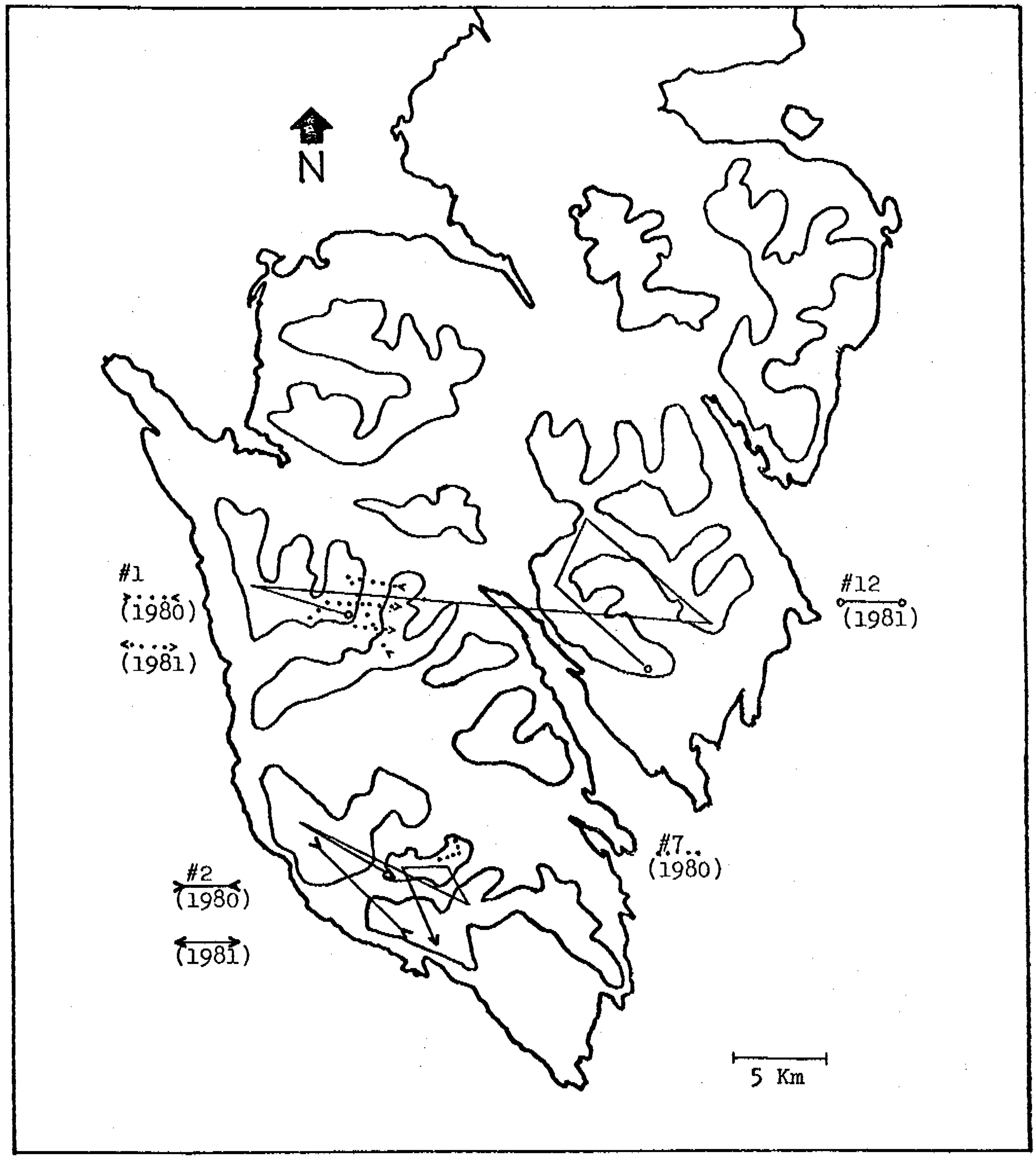

Figure 4. Movements of radio-collared male goats on the lower Cleveland Peninsula, October 20 - December 15, 1980 and 1981.

size, "N_e" of 30, (Wilson 1976, p. 77). Allowing for a limited amount of immigration to the population from surrounding areas, such a population can be estimated to have an average coefficient of genetic relationship, "r", of approximately .35 (Brown 1974, p.70). From this "r", it is possible to calculate the inbreeding coefficient, "F", which equals .26. Due to the sedentary nature of females, these goats obviously violate the assumption of free genetic exchange, so this estimated "F" value is conservative.

Theoretical arguments (Crow and Kimura 1970, Wilson 1975) supported by empirical data (Preobrazhenskii 1961, cited by Geist 1971; Ralls et. al. 1980) indicate that inbreeding in ungulates reduces juvenile survival and reproductive performance of adult females. Ralls et. al. (1979) demonstrated that "F" values as slow as .25 resulted in significantly reduced reproductive success in 15 of 16 ungulate species studied. Thus inbreeding may play a role in the below-average percentage of kids on the lower Cleveland Peninsula compared to larger nearby populations. Deleterious effects of limited genetic variability may compound small group size on the lower Cleveland Peninsula. The inter-ridge movements by males serve to insure genetic exchange between groups, and any decline in "effective population size" as a consequence of increased mortality or reduced movement of males between ridge complexes will intensify potential complications of inbreeding and decrease viability of sub-populations.

To date human impact on this population has been minimal. Although the area is open to hunting from 1 August to 31 December, harvest has averaged less than 1 goat per year since 1975 (ADF&G unpubl. data). Habitat alteration in the past was confined to small scale placer mining and logging of a few select spruce stands along the shoreline. Future human impacts may be substantial.

Current plans for logging on the Cleveland Peninsula call for the annual construction of 25 km of road and harvest of 15 million board feet of timber per year over the period 1985-2015, with slightly less activity over the remaining 70 years of the rotation. Due to the distribution of commercial timber, virtually every valley eventually will be logged and/or roaded to some extent. There will be 100-120 people involved in harvesting this timber.

Chadwick (1973) demonstrated that goats may abandon habitat, at least temporarily,as a result of road building activity. Similar responses by goats on the lower Cleveland Peninsula could have grave results. Female goats forced to abandon one ridge could spend substantial time searching unfavorable forest areas for another patch of suitable habitat. During this time they would be relatively vulnerable to predation by bears (<u>Ursus arctos</u> and <u>U. americanus</u>) and wolves (<u>Canis lupus</u>).

Furthermore, although no reliable estimates can be made of carrying capacity of individual ridges, observations indicate that many of the preferred browse species (eg. <u>Vaccinium</u> spp.) show substantial hedging in some areas (ADF&G unpubl. data). If existing groups are currently limited by available forage resources, goats displaced from one ridge might not be able to survive even if they located another patch of occupied habitat.

Road construction, logging activities and slash in clear cuts may also affect the movements of males during the rut directly by creating barriers or indirectly as a result of human harassment or killing of goats. Although the hunting season will be permanently closed as soon as development begins, illegal hunting can be expected to occur. Given the limited number of animals in this population, even occasional poaching along the road system could substantially alter gene flow between, or viability of, sub-populations.

The goats on the lower Cleveland Peninsula exist at the marginal end of the scale in group size, available habitat and, possibly, genetic variability. Maintainence of sub-populations is tenuous under optimal conditions. Human activity of the magnitude currently planned for the area may have significant effects on mortality and inter-ridge movements by males during the rut and thus eventually result in the elimination of several, if not all, sub-populations.

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